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# REPORT OF THE SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES ON

# assessment of *Merluccius merluccius*, *Mullus barbatus*, *Mullus surmuletus*, *Boops boops*, *Spicara smaris/Spicara flexuosa* and *Nephrops norvegicus* in Aegean and Ionian waters

# (STECF 12-21)

Edited by Massimiliano Cardinale & Giacomo-Chato Osio

This report was reviewed by the STECF during its 41th plenary meeting held from 5 to 9 November, 2012 in Brussels, Belgium

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**THIS REPORT WAS REVIEWED DURING THE PLENARY MEETING HELD IN BRUSSELS 5 – 9 November 2012**

## Background

EU Member States were requested to develop and adopt multiannual management plans for fisheries carried out in their waters (Article 19 of the Council Regulation EC No 1967/2006; OJ L36 of 8.2.2007 hereinafter "Mediterranean Regulation"). By their characteristics (e.g. mixed fisheries) and limited extension of waters jurisdiction in the Mediterranean most of those fisheries may also exploit straddling stocks.

Those plans shall be built on the basis of management and conservation reference points such as targets and limits against which evaluate the sustainable exploitation and the recovery to or the maintenance of stocks within safe biological limits (e.g. population size and/or long-term yields and/or fishing mortality rate and/or stability of catches). The management plans shall be drawn up on the basis of the precautionary approach to fisheries management and shall ensure the sustainable exploitation of stocks and that impact of fishing activities on marine eco-systems is kept at sustainable levels.

Within this framework Greece presented the scientific basis and state of stocks underpinning a likely management plan for demersal trawl fisheries in the Aegean and Ionian seas (GSA 22&23 and GSA 20, respectively); the stock assessments were based on a logistic surplus production model within a non-equilibrium approach.

Taking into account previous positions taken by STECF[1] on the basic characteristics of data to apply

[1] Scientific, Technical and Economic Committee for Fisheries (STECF) - Assessment of Mediterranean Stocks Part I (eds. Cardinale, M., Cheilari, A. & Rätz, H.-J.). 2010. Publications Office of the European Union, Luxembourg, EUR 24637 EN, JRC 62020, 1077 pp.

the surplus production models, STECF EWG 12-10 was requested to review the assessment of hake and red mullet stocks as presented by the Greek authorities. STECF EWG 12-10 position, which will be examined at the next STECF November plenary, indicates that the applied models were generally found to explain a very small part of the variance observed in the dataset and that the assessments were not considered adequate (lack of contrast in the level of effort, shortness of the time series, lack of biomass baselines at low level of exploitation, etc) to provide reliable estimates of F and B. Age-based method (e.g. YPR and LCA) were considered most adequate for the kind of data available following the various data calls. Therefore, the very informative "Kobe plots" were considered not adequate to represent the evolution of the actual state of the stocks.

Data uploaded by Greece following the official data calls are incomplete and quite old, since their data collection stop essentially at 2007-2008; it is however advisable to explore further assessments both trough age-based methods (LCA, YPR), SURBA and to re-run the production model including longer and more contrasted data sets on catches and effort. These longer catch and effort data sets are in fact available both through the EC study EVOMED[2] and new data sets outcomes of the FP7 ECOKNOWS project and partially published on JBR[3] (data sets available on-line http://www.jbr.gr). These data sets will be made available by EC and the Authors of the JBR paper on the JRC ftp.

Access and use of data is authorized only for the purpose of this work, no other work and distribution is allowed outside the meeting without the written authorization by the concerned services of the European Commission.

The stocks to be evaluated (both Aegean and Ionian waters whenever possible) will concern the following species: *Merluccius merluccius*, *Mullus barbatus*, *Mullus surmuletus*, *Boops boops*, *Spicara smaris/Spicara flexuosa* and *Nephrops norvegicus*. The EWG is however free to add more demersal species if considered relevant for the demersal fisheries and available data sets are considered adequate to use age-based methods or surplus production models.

**Terms of reference**

- Provide the trends and relative importance of Greece catches of the selected species with respect to catches of other Mediterranean countries fishing in the Aegean and Ionian Sea (GSA 22&23 and GSA 20, respectively). Scientific and official statistics for capture fisheries available in different data sources have to be adequately scrutinized, compared, used and commented as needed to provide a sound and complete picture of trends in catches and fishing effort by different countries operating in

[2] " Understanding size developments of exploited stock and ecosystems in the Mediterranean by using private fishermen's tally-books and historical information" (EC-DG MARE Contract N° 512.539097 Lot 4)

[3] "Spatial disentangling of Greek commercial fisheries landings by gear between 1928-2007" by Moutopoulos D. K. and Stergiou I. K (2012). Journal of Biological Research-Thessaloniki 18: 265-279.

the GSAs under examination (e.g. DCFR calls; GFCM and FAO-Global capture production data bases (http://www.gfcm.org/gfcm/topic/17105/en); GFCM-TASK 1 Statistical Bulletin (http://www.gfcm.org/gfcm/topic/17106/en) ; EVOMED; JBR study. Assumptions and criteria to fill possible gaps in the time series and to split the data by GSA have to be described and documented.

- Advise whether, how and for which species the lack of catches of countries other than Greece could substantially affect the outcomes of the analysis. Provide sound assumptions (e.g. relative importance of catches, similar/dissimilar exploitation patterns, fishing effort/fishing capacity evolution, etc.) that may mitigate the counterproductive effects and can make acceptable the outcomes of the assessments even though obtained from analysis of partial data-sets;

- Evaluate, by using both age/size based methods on commercial and scientific surveys data (e.g. LCA, YPR, SURBA) and surplus production models (ASPIC), the evolution of fishing mortality, the state of the stocks, as updated at the most recent years available in the time series. The methods, input parameters and conclusions have to be fully documented and justified (diagnostics, input –output tables etc.).

- Provide management and conservation reference points with respect to MSY management objective and safe biological limits;

- Provide rationale and explanations (e.g. selectivity, growth, maturity etc) that justify the estimation of currently valid reference points with older data sets.

- analyze trends in fishing efforts and fishing capacity, or other suitable indicators, and indicate whether the current state of exploited resources could somehow be inferred from the results of the abovementioned analysis carried out on data-sets till 2008.

**STECF observations**

The stocks for which evaluation were requested were: *Merluccius merluccius, Mullus barbatus, Mullus surmuletus, Boops boops, Spicara smaris, Spicara flexuosa* and *Nephrops norvegicus* related to both Aegean and Ionian geographic sub-areas. STECF was also requested to assess additional demersal species if data sets suitable for applying age-based methods or surplus production models were available.

A selected group of experts from several Mediterranean countries, including 3 experts from Greece participated in the WG. The assessment approaches undertaken were dependent on the availability of appropriate data and information which in some cases was rather limited in terms of the demographic structure of the commercial catches, the length of the time series or poor quality. It was requested to carry out new assessments using both commercial catch and surveys data. Catch at age-based methods as LCA or SURBA, using data derived from DCF as well as non-equilibrium production models using longer and more contrasted data sets derived from EC funded studies as EVOMED and from outcomes of the FP7 ECOKNOWS were suggested as possible approaches.

A number of problems were encountered with trying to reconstruct the demographic structure of the catches using different data sources, which limited the length of the time-series of data for input to LCA. No data on discards were available. Even though a much longer data series of catch and effort by gear and area was available for fitting a dynamic production model (ASPIC) a number of gaps and inconsistencies remained, which decreased the quality of such data series. For some stocks, estimates for biological parameters used as model inputs were not available.

Data were derived from a number of sources. The primary source was data supplied by the National Statistical Service of Greece (NSSH). STECF notes that NSSH data suffer from many biases, greatest for inshore fisheries, and the extent of such bias cannot be easily estimated (Stergiou et al. 1997, Papaconstantinou 2002). In addition, NSSH did not provide data for boats smaller than 10 m or 20 HP, which represent a large proportion (up to 30%) of the fishing fleet in terms of number of vessels.

The reconstructed time series used for the assessments, provides estimates of the species composition of landings of small vessels (<10 m) using information from a technical report that relates to the period 1996-2000 only (Anon., 2001). Hence, STECF considers that the resulting species compositions are unlikely to be representative of the true species composition throughout the whole time series. Furthermore, as corrections/conversions of landings and effort data for the different species and fleet categories were based on many different data sources, STECF is unable to provide an informed opinion on the reliability of the reconstructed time-series. For example, the reconstructed time series of landings for the period 2003-2008 does not match the time series of landings for that period reported under the DCF.

Data on fishing effort are only provided as total effort by gear type or gear group without any distinction by métier and as such did not permit the quantification of species-specific effort or to examine any potential changes in fleet behaviour.

For the standardization of effort, days at sea x kW were used. To account for potential increases in technical efficiency over time, an increase of 2.74% per year, based on estimates from trawl fisheries in the Western Mediterranean was used. STECF has no basis to judge whether the value of 2.47% per year is representative of the vessels in the Greek fleet.

The relatively short abundance index time-series derived from the MEDITS trawl surveys meant that they were unsuitable as auxiliary tuning series for the ASPIC production models. Moreover, for some of the ASPIC assessments, model fit was poor and the assessments were considered unreliable.

SURBA was used in some cases for estimation of recruitment, spawning stock, relative fishing mortality rate and for observing trends in these parameters, but its use was limited because in some years surveys were not conducted.

**STECF conclusions and recommendations**

STECF notes that based on trends in fishing effort and landings and information on age structure of the commercial catch by gear and surveys data, assessments of the stock status (up to 2008) for all the requested stocks in all the GSAs were undertaken. Given the available data and information, the results from the ASPIC dynamic production model are the most informative even though the results need to be considered as uncertain.  However, STECF notes that for stocks where more than one assessment model could be performed, the results from the different approaches were generally consistent.

STECF considers that the data set used, represents a first attempt to reconstruct the historical catch composition currently available for the stocks and fisheries in the different GSAs considered. However, STECF is unable to judge how representative the reconstructed data set is of the true historical catch composition.

Given that the assessments carried out are based on data up to 2008 only, STECF considers that the results should only be taken to be an indication of the trends in exploitation status and stock biomass over the historic time series and may not be representative of the current status.

Notwithstanding the concerns with regard to the representativeness of the reconstructed time-series of data, STECF considers that all of the terms of Reference have been addressed to the best extent possible.

**References**

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Stergiou, K. I., Christoub, E. D. & Petrakis, G. (1997). Modelling and forecasting monthly fisheries catches: comparison of regression, univariate and multivariate time series methods. Fisheries Research, 29 (1), 55–95.

Papaconstantinou, C., Kavadas, S., Tsimenidis, N., Economou, A. N. & Bazigos, G. (2002). Design of a system for the collection and compilation of basic fisheries statistics in the Mediterranean: A case study for Greece. Fisheries Research, 57 (2), 155-167.

# REPORT TO THE STECF

## AD-HOC EXPERT WORKING GROUP ON assessment of *Merluccius merluccius*, *Mullus barbatus*, *Mullus surmuletus*, *Boops boops*, *Spicara smaris/Spicara flexuosa* and *Nephrops norvegicus* in Aegean and Ionian waters

**By correspondence in October 2012**

Report of the Ad-hoc working group on the assessment of some Greek stocks

Executive summary

The STECF Ad-hoc Working Group on the assessment of some Greek stocks did meet by correspondence during October 2012. The meeting was chaired by Massimiliano Cardinale and attended by 9 experts in total, including 4 STECF members, and 1 JRC staff (Annex I).

The ToRs were addressed by using the data provided through several DCF data call and also data collated during EC study EVOMED, and new data sets derived from the FP7 ECOKNOWS project. The Ad-hoc working group conducted the assessment of 14 stocks in GSA 20 and 22&23. The assessments were conducted using several methods and data sources, i.e. information of landings and effort were used to run production models (i.e. ASPIC), data collected during MEDITS were used to run SURBA and information on the size structure of the catches were used for running LCA and YPR using VIT. The biological parameters were obtained by previous SGMED-STECF reports or from literature sources and are fully documented in each stock specific section of the report. The list of the stocks and methods used for each stock in the different areas is presented in Table 1.

Table 1. List of the stocks and methods used for each stock in the different GSAs.

| GSA | Species | LCA | ASPIC | YPR | SURBA | Effort and landings data |
|---|---|---|---|---|---|---|
| 20 | *Boops boops* | | X | | X | X |
| 20 | *Mullus barbatus* | X | X | X | X | X |
| 20 | *Mullus surmuletus* | | X | | | X |
| 20 | *Spicara smaris* | | X | | X | X |
| 20 | *Merluccius merluccius* | X | X | X | X | X |
| 20 | *Nephrops norvegicus* | | X | | X | X |
| 20 | *Spicara flexuosa* | | X | | X | X |
| *22&23* | *Merluccius merluccius* | X | X | X | X | X |
| 22&23 | *Nephrops norvegicus* | X | X | X | X | X |
| 22&23 | *Mullus barbatus* | X | X | X | X | X |
| 22&23 | *Mullus surmuletus* | | X | | X | X |
| 22&23 | *Boops boops* | | X | | X | X |
| 22&23 | *Spicara smaris* | | X | | X | X |
| 22&23 | *Spicara flexuosa* | | X | | X | X |

The assessments of recent and historic stock parameters and fisheries as well as the management advice provided in the present report are constrained for the Greek Geographical Subareas (GSA). The assessments of exploited stocks and fisheries estimated the stocks' exploitation status, which was evaluated against the proposed $F_{MSY}$ and $B_{MSY}$ limits.

The STECF Expert Ad-hoc Working Group on the assessment of some Greek stocks also stress the fact that the reconstructed landings might differ from the official DCR-DCF landings depending on the source of the data and of the methodology used for estimating the landings. However, reconstructed landings are the longest time series available. Future corrections of the reconstructed landings (i.e. adding discards, illegal and unreported landings) as well as tuning the reconstructed landings on other sources (i.e. example given DCR-DCF) is underway for the near future. These differences might affect the application and the results of the different models used (i.e. ASPIC).

**Conclusions of the working group**

The STECF Expert Ad-hoc Working Group on the assessment of some Greek stocks assessed the status of 14 demersal stocks and their fisheries, which resulted in an estimate of the current fishing mortality and level of biomass compared to $F_{MSY}$ and $B_{MSY}$. Seven stocks were considered exploited unsustainably, 5 were assessed to be exploited sustainable and for 1 stock it was not possible to determine the stock status.

The STECF Expert Ad-hoc Working Group on the assessment of some Greek stocks provided for the assessed stocks detailed summary sheets informing about the stocks' status and their state of exploitation in relation to proposed management reference points consistent with high long term yields ($F_{MSY}$ and $B_{MSY}$).

The STECF Expert Ad-hoc Working Group on the assessment of some Greek stocks concludes that the:

- Norway lobster (*Nephrops norvegicus*), European hake (*Merluccius merluccius*), red mullet (*Mullus barbatus*), striped red mullet (*Mullus surmuletus*), blotched picarel (*Spicara flexuosa*) and picarel (*Spicara smaris*) in GSA 22&23 are exploited unsustainably
- Bogue in GSA 22&23 is exploited sustainably
- Norway lobster and European hake in GSA 20 are exploited unsustainably
- Blotched picarel, picarel, red mullet, bogue and striped red mullet in GSA 20 are exploited sustainably

| GSA | Species | $F/F_{MSY}$ | $B/B_{MSY}$ | $F_{01}$ | $F_{current}$ | Status of F | Status of B |
|---|---|---|---|---|---|---|---|
| 20 | *Boops boops* | NA | NA | | | NA | NA |
| 20 | *Mullus barbatus* | 0.65 | 1.21 | 0.53 | 0.67 | Sustainably exploited | Above $B_{MSY}$ |
| 20 | *Mullus surmuletus* | 0.83 | *0.88* | | | Sustainably exploited | Below $B_{MSY}$ |
| 20 | *Spicara smaris* | 0.30 | 1.15 | | | Sustainably exploited | Above $B_{MSY}$ |
| 20 | *Merluccius merluccius* | NA | NA | 0.27 | 0.89 | Exploited unsustainably | |
| 20 | *Nephrops norvegicus* | 2.06 | 0.18 | | | Exploited unsustainably | Below $B_{MSY}$ |
| 20 | *Spicara flexuosa* | 0.42 | 1.58 | | | Sustainably exploited | Above $B_{MSY}$ |
| *22&23* | *Merluccius merluccius* | *NA* | *NA* | *0.24* | *0.83* | *Exploited unsustainably* | |
| 22&23 | *Nephrops norvegicus* | 1.61 | 0.62 | 0.12 | 0.32 | Exploited unsustainably | Below $B_{MSY}$ |
| 22&23 | *Mullus barbatus* | 1.18 | 0.91 | 0.52 | 0.56 | Exploited unsustainably | Below $B_{MSY}$ |
| 22&23 | *Mullus surmuletus* | 1.12 | 0.88 | | | Exploited unsustainably | Below $B_{MSY}$ |
| 22&23 | *Boops boops* | 0.62 | 0.66 | | | Sustainably exploited | Below $B_{MSY}$ |
| 22&23 | *Spicara smaris* | 1.67 | 0.21 | | | Exploited unsustainably | Below $B_{MSY}$ |
| 22&23 | *Spicara flexuosa* | 1.25 | 0.60 | | | Exploited unsustainably | Below $B_{MSY}$ |

**Recommendations of the working group**

The STECF Expert Ad-hoc Working Group on the assessment of some Greek stocks recommends the reduction of the effort and/or the catches of the relevant fleets' catching the following stocks until fishing mortality is below or at the proposed level $F_{MSY}$, in order to avoid future loss in stock productivity and landings: Norway lobster, European hake, red mullet, striped red mullet, blotched picarel and picarel in GSA 22&23, Norway lobster, European hake in GSA 20. This target should be reached by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches and effort consistent with $F_{MSY}$ should be estimated. Bogue in GSA 22&23 and Blotched picarel, picarel, red mullet, bogue and striped red mullet in GSA 20 are exploited sustainably and their fishing mortality should be kept at the current level.

Introduction

The STECF Expert Ad-hoc Working Group on the assessment of some Greek stocks did meet by correspondence during October 2012. The meeting was chaired by Massimiliano Cardinale and attended by 9 experts in total, including 4 STECF members and 2 JRC staff (Annex I).

Three online skype meetings were held, on the 17$^{th}$, 24$^{th}$ and 29$^{th}$ of October.

The structure of the present report is in accordance with the terms of reference to STECF, as defined in the following chapter and also follows the general structure of previous SGMED reports.

#### 1.1.1 *Introduction to the Terms of References (TORs)*

EU Member States were requested to develop and adopt multiannual management plans for fisheries carried out in their waters (Article 19 of the Council Regulation EC No 1967/2006; OJ L36 of 8.2.2007 hereinafter "Mediterranean Regulation"). By their characteristics (e.g. mixed fisheries) and limited extension of waters jurisdiction in the Mediterranean most of those fisheries may also exploit straddling stocks.
Those plans shall be built on the basis of management and conservation reference points such as targets and limits against which evaluate the sustainable exploitation and the recovery or the maintenance of stocks within safe biological limits (e.g. population size and/or long-term yields and/or fishing mortality rate and/or stability of catches). The management plans shall be drawn up on the basis of the precautionary approach to fisheries management and shall ensure the sustainable exploitation of stocks and that impact of fishing activities on marine eco-systems is kept at sustainable levels.
Within this framework Greece presented the scientific basis and state of stocks underpinning a likely management plan for demersal trawl fisheries in the Aegean and Ionian seas (GSA 22&23 and GSA 20, respectively); the stock assessments were based on a logistic surplus production model within a non-equilibrium approach.

Taking into account previous positions taken by STECF[1] on the basic characteristics of data to apply the surplus production models, STECF EWG 12-10 was requested to review the

[1] SGMED 10-02 as endorsed by the STECF

assessment of hake and red mullet stocks as presented by the Greek authorities. STECF EWG 12-10 position, which will be examined at the next STECF November plenary, indicates that the applied models were generally found to explain a very small part of the variance observed in the dataset and that the assessments were not considered adequate (lack of contrast in the level of effort, shortness of the time series, lack of biomass baselines at low level of exploitation, etc) to provide reliable estimates of F and B. Age-based method (e.g. YPR and LCA) were considered most adequate for the kind of data available following the various data calls. Therefore, the very informative "Kobe plots" were considered not adequate to represent the evolution of the actual state of the stocks.

Data uploaded by Greece following the official data calls are incomplete and quite old, since their data collection stop essentially at 2007-2008; it is however advisable to explore further assessments both trough age-based methods (LCA, YPR), SURBA and to re-run the production model including longer and more contrasted data sets on catches and effort. These longer catch and effort data sets are in fact available both through the EC study EVOMED[2] and new data sets outcomes of the FP7 ECOKNOWS project and partially published on JBR[3] (data sets available on-line http://www.jbr.gr). These data sets will be made available by EC and the Authors of the JBR paper on the JRC ftp.
Access and use of data is authorized only for the purpose of this work, no other work and distribution is allowed outside the meeting without the written authorization by the concerned services of the European Commission.

The stocks to be evaluated (both Aegean and Ionian waters whenever possible) will concern the following species: *Merluccius merluccius, Mullus barbatus, Mullus surmuletus, Boops boops, Spicara smaris/Spicara flexuosa* and *Nephrops norvegicus*. The EWG is however free to add more demersal species if considered relevant for the demersal fisheries and available data sets are considered adequate to use age-based methods or surplus production models.

### 1.1.2 *TORs*

- Provide the trends and relative importance of Greece catches of the selected species with respect to catches of other Mediterranean countries fishing in the Aegean and Ionian Sea (GSA 22&23 and GSA 20, respectively). Scientific and official statistics for capture fisheries available in different data sources have to be adequately scrutinized, compared, used and commented as needed to provide a sound and complete picture of trends in catches and fishing effort by different countries operating in the GSAs under examination (e.g. DCFR calls; GFCM and FAO-Global capture production data bases (http://www.gfcm.org/gfcm/topic/17105/en); GFCM-TASK 1 Statistical Bulletin (http://www.gfcm.org/gfcm/topic/17106/en) ; EVOMED; JBR study ). Assumptions and criteria to fill possible gaps in the time series and to split the data by GSA have to be described and documented.

- Advise whether, how and for which species the lack of catches of countries other than Greece could substantially affect the outcomes of the analysis. Provide sound assumptions

[2] " Understanding size developments of exploited stock and ecosystems in the Mediterranean by using private fishermen's tally-books and historical information" (EC-DG MARE Contract N° 512.539097 Lot 4)
[3]" Spatial disentangling of Greek commercial fisheries landings by gear between 1928-2007" by Moutopoulos D. K. and Stergiou I. K (2012). Journal of Biological Research-Thessaloniki 18: 265-279.

(e.g. relative importance of catches, similar/dissimilar exploitation patterns, fishing effort/fishing capacity evolution, etc.) that may mitigate the counterproductive effects and can make acceptable the outcomes of the assessments even though obtained from analysis of partial data-sets;

- Evaluate, by using both age/size based methods on commercial and scientific surveys data (e.g. LCA, YPR, SURBA) and surplus production models (ASPIC), the evolution of fishing mortality, the state of the stocks, as updated at the most recent years available in the time series. The methods, input parameters and conclusions have to be fully documented and justified (diagnostics, input –output tables etc.).

- Provide management and conservation reference points with respect to MSY management objective and safe biological limits;

- Provide rationale and explanations (e.g. selectivity, growth, maturity etc), which justify the estimation of currently valid reference points with older data sets.

- Analyze trends in fishing efforts and fishing capacity, or other suitable indicators, and indicate whether the current state of exploited resources could somehow be inferred from the results of the above mentioned analysis carried out on data-sets till 2008.

Section 1

1.1.3 *Description of landings and fishing effort time series*

**Input parameters**

*Fisheries landings*

Greek fisheries landings used in the present report were derived from the landings reconstructed for the period between 1964 and 2007, which were based on the aggregation of fisheries landings reported by different organizations authorized for the collection of fisheries data (for more details see Table 1 and from Moutopoulos and Stergiou, 2012):

(a) Hellenic Statistical Authority (HELSTAT) during 1964-1969 recorded landings by subarea from all engined-powered vessels and since 1970 recorded landings data excluding the small-scale vessels with engine power < 19 HP;

(b) Agricultural Statistics of Greece (ASG) that recorded the landings, by prefecture, from small-scale vessels with engine power < 19 HP during 1974-2007;

(c) the landings per species, gear (i.e., trawls, purse-seines, beach-seines and other small-scale gears operated from vessels with engine power > 19 HP) and subarea during 1990-2007 that have been recorded by HELSTAT but have never been published or presented before (provided to us by Mrs Aik. Nasiakou, HELSTAT) and thus were not accessible to the entire scientific community.

A complete description of the reconstruction is presented in Moutopoulos and Stergiou (2012). The reconstruction methodology is the same with that used for the reconstruction of global fisheries landings as well as of the landings per country (Zeller and Pauly, 2007). It is noted that the reconstructed landings, so far, do not incorporate:

1. the temporal structural changes in fishing effort, both in terms of the number of vessels by gear type (changes in the ratio of participation of the different gears) and in fishing intensity by gear type (through modernization of fishing vessels and gear);

2. data from professional rowing vessels;

3. discards;
4. recreational landings and;

5. illegal and unreported landings.

The reconstructed landings were disagreggated by GSA by adding the reconstructed landings per subarea as follows:

(i) GSA 20 included the Greek subareas S3, S4, S5, S6 and S9, and;

(ii) GSA 22&23 included the subareas S7, S8, S10, S11, S12, S13, S14, S15, S16, S17 and S18.

It is also important to notice that the reconstructed landings might differ from the official DCR-DCF landings depending on the source of the data and of the methodology used for estimating the landings. However, reconstructed landings are the longest time series available. Future corrections of the reconstructed landings (i.e. adding discards, illegal and unreported landings) as well as tuning the reconstructed landings on other sources (i.e. example given DCR-DCF) is underway for the near future. These differences might affect the application and the results of the different models used (i.e. ASPIC).

*Fishing effort*

Fishing effort data (i.e. number of fishing vessels, engine horse power expressed in kilowatt (KW) and vessel tonnage in gross tonnage (GT) were based on data provided by different statistical organizations for Greek waters between 1964 and 2007 as shown in Table 2. In particular, fishing effort data per gear (i.e. trawls, purse-seines, beach-seines and small-vessels) were derived from the records of HELSTAT and ASG for the period 1964-1990, whereas for the years 1991 to 2007, fishing effort data were obtained from the DCR database.

Fishing effort data for the period 1964-1990 was disaggregated by GSA based on the bootstrapped mean of the proportions of the fishing effort values per each GSA derived from DCR data collected between 1991 and 2008.

Table 1. Summary of the fisheries landing statistics recorded by the different statistical organizations for Greek waters between 1964 and 2007 (modified from Moutopoulos and Stergiou, 2012).

| Period | Fishery type | Species resolution | Gear type | Spatial resolution (i.e. Fig. 1) | Source |
|---|---|---|---|---|---|
| 1964-1969 | Marine | 17 fish, 4 cephalopods and 1 crustacean | All gear types combined for all engined vessels | For 16 fishing subareas | NSSG |
| 1964-1969 | Marine | Total landings (i.e., all species combined) | Per gear type (i.e. trawl, purse-seine, beach-seine and other small-scale) for all engined vessels | For 16 fishing subareas | NSSG |
| 1964-2007 | Marine | *Auxis thazard*, *Euthynnus alletteratus*, *Thunnus* spp. and *Xiphias gladius* | All gear types combined for all engined vessels | Total for Greek waters | ICCAT |
| 1970-1981 | Marine | 17 fish, 4 cephalopods and 1 crustacean | All gear types combined excluding small vessels | For 16 fishing subareas | NSSG |
| 1970-1989 | Marine | Total landings (i.e., all species combined) | Per gear type (i.e. trawl, purse-seine, beach-seine and other small-scale) excluding small vessels | For 16 fishing subareas | NSSG |
| 1982-1989 | Marine | 56 fish, 5 cephalopods and 5 crustaceans | All gear types combined excluding small vessels | For 16 fishing subareas | NSSG |
| 1990-2007 | Marine | 56 fish, 5 cephalopods and 5 crustaceans | Per gear type (i.e. trawl, purse-seine, beach-seine and other small-scale) excluding small vessels | For 16 fishing subareas | NSSG unplished data (Nasiakou Aik. pers. comm.) |
| 1975-1994 | Marine | Mean total (i.e. all species[i] combined) annual landings per vessel | Small-scale vessels with engine power < 19 HP | Total for Greek waters | ASG |
| 2002-2006 | Marine | Total (i.e. all species[i] combined) annual landings per vessel | Small-scale vessels with engine power < 19 HP | For 41 prefectures | ASG |

*Marine landings were estimated by the proportion (equal to 0.735) of the Greek marine landings to the total (i.e. marine, lagoons and freshwater, excluded the landings from overseas) landings in 1939 (GSSG, 1934-1940).

[+]Marine landings were estimated by the proportion (equal to 0.840) of the Greek marine landings to the total (i.e. marine, lagoons and freshwater, excluded the landings from overseas) landings in 1956 from data published by Ananiadis (1968).

[i]Bivalve species were excluded from the reconstruction of the fisheries landings from both large-engined and small-engined vessels, from which a large proportion of the reported values are derived from intensive farming in coastal sea (Mitsoudi *et al*., 2006).

Table 2. Summary of the fisheries effort statistics (number of fishing vessels, engine horsepower (HP) and vessels tonnage (GT)) recorded by the different statistical organizations for Greek waters, 1964-2007. GSSG, General Statistical Service of Greece; HELSTAT, Hellenic Statistical Authority; ASG, Agricultural Statistics of Greece; and DCR, Data Collection Registry.

| Period | Fishing effort type | Gear type | Spatial resolution | Source |
|---|---|---|---|---|
| 1964-1990 | Number of vessels / engine horsepower (HP) / vessel tonnage (GT) / number of fishers | Per gear type (i.e. trawl, purse-seine, beach-seine and other small-scale) excluding small-scale vessels with engine power < 19 HP | Total for Greek waters | HELSTAT |
| 1970-1974 | Number of vessels | Small-scale vessels with engine power < 19 HP | Total for Greek waters | Tsikliras *et al*. (2007) |
| 1975-1990 | | | For 41 prefectures | ASG |
| 1991-2007 | | Per gear type (i.e. trawl, purse-seine, beach-seine and other small-scale) | For 178 fishing ports | DCR (EC, 1998) |

### 1.1.4 *Results*

*Landings*

The studied species represented 20.9% of the total Greek landings during 1964-2007, with picarel, bogue and hake dominating (5.4%, 5.7% and 4.3, respectively) followed by red mullet, surmulet, blotched picarel and Norway lobster, which represented less than 2.3% of the total. The aforementioned species represented 27.1% of the total landings for all Greek waters during 1964-2007 (Table 3). Table 3 also shows the landings of each species per gear for the two studied areas.

Table 3. Species composition (%) per gear (i.e. trawls (OTB), purse seines (PS), beach seines (SV), gill nets, trammel nets and long lines (GNS, GTR and LLS)) and study area.

| All areas combined | All gears combined | OTB | PS | SV | GNS/GTR/LLS |
|---|---|---|---|---|---|
| Bogue | 5.7 | 2.9 | 8.4 | 9.0 | 4.6 |
| Hake | 4.3 | 9.4 | 0.2 | 1.6 | 5.6 |
| Red mullet | 2.3 | 6.1 | 0.1 | 2.2 | 2.5 |
| Surmulet | 1.8 | 3.0 | 0.1 | 1.3 | 2.5 |
| Blotched picarel | 0.8 | 2.2 | 0.1 | 0.9 | 0.7 |
| Picarel | 5.4 | 6.9 | 1.9 | 44.9 | 2.2 |
| Norway lobster | 0.5 | 2.1 | 0.0 | 0.1 | 0.3 |
| GSA 20 | | | | | |
| Bogue | 5.9 | 5.2 | 8.6 | 9.5 | 4.9 |
| Hake | 7.3 | 10.9 | 0.2 | 2.7 | 8.8 |
| Red mullet | 3.2 | 6.5 | 0.2 | 1.4 | 3.3 |
| Surmulet | 1.3 | 1.4 | 0.1 | 0.7 | 1.7 |
| Blotched picarel | 2.2 | 10.6 | 0.2 | 2.7 | 0.5 |
| Picarel | 7.1 | 11.4 | 2.8 | 49.2 | 1.7 |
| Norway lobster | 0.1 | 0.2 | 0.0 | 0.1 | 0.1 |
| GSA 22&23 | | | | | |
| Bogue | 5.5 | 2.0 | 7.9 | 8.6 | 4.6 |
| Hake | 3.9 | 9.4 | 0.2 | 1.4 | 5.1 |
| Red mullet | 2.2 | 6.1 | 0.1 | 2.3 | 2.4 |
| Surmulet | 1.8 | 3.2 | 0.1 | 1.3 | 2.6 |
| Blotched picarel | 0.6 | 1.0 | 0.1 | 0.5 | 0.7 |
| Picarel | 4.9 | 5.1 | 1.6 | 43.8 | 2.2 |
| Norway lobster | 0.6 | 2.5 | 0.0 | 0.2 | 0.4 |

The most representative species per gear for the two areas are hake, picarel and red mullet for trawls, bogue in purse-seines, picarel in beach seines and hake and bogue in the small-scale fisheries.

The official landings of each species by gear in GSA 20 and in GSA 22&23 are given in Figures 1 and 2, respectively. Species per gear type and area exhibited variability during 1964-2007, with the most cases shown an increasing trend from 1964 to the mid 1990's.

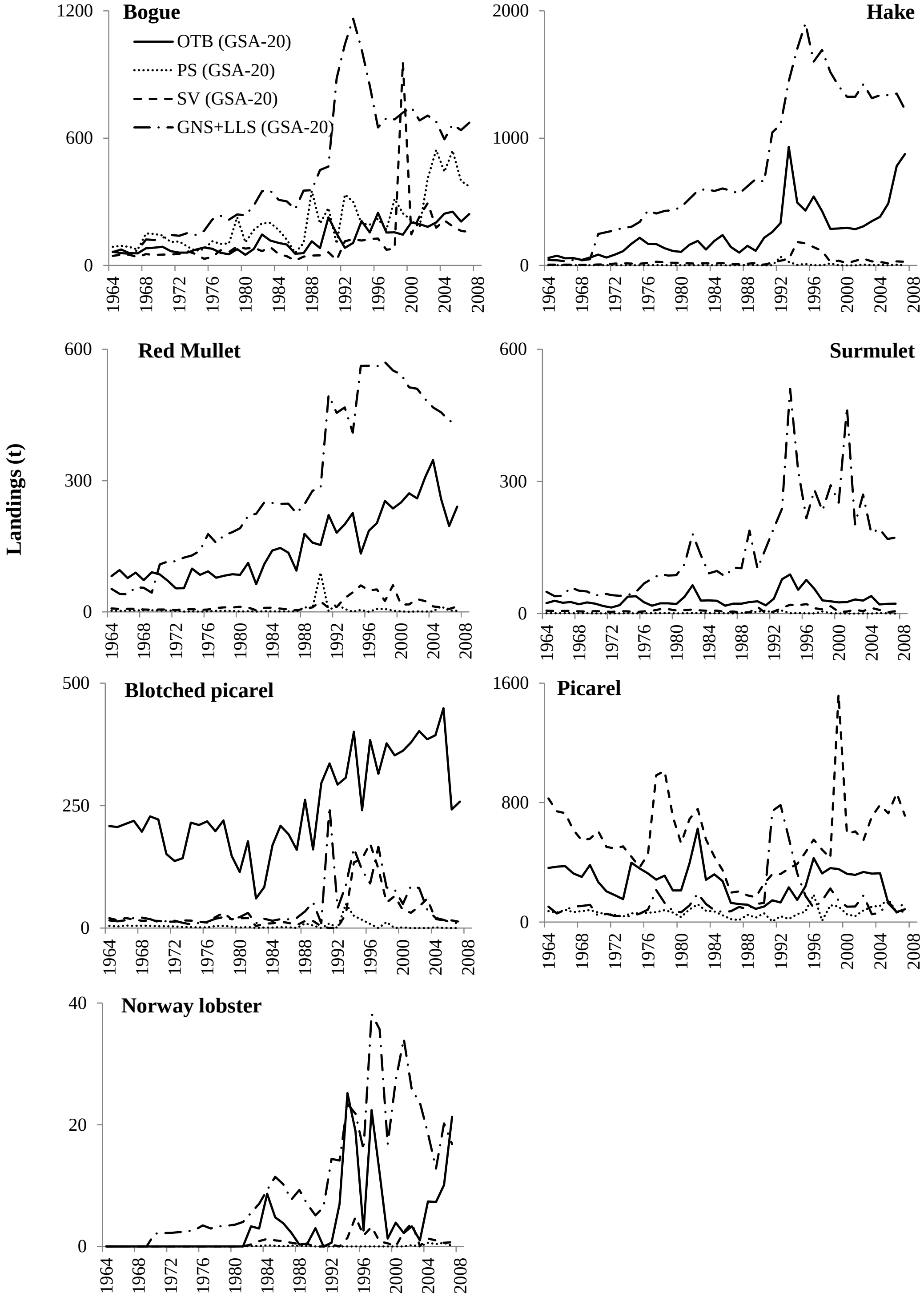


Figure 1. Annual species landings per gear (OTB, PS, SV and GNS and LLS) in GSA 20, 1964-2007.

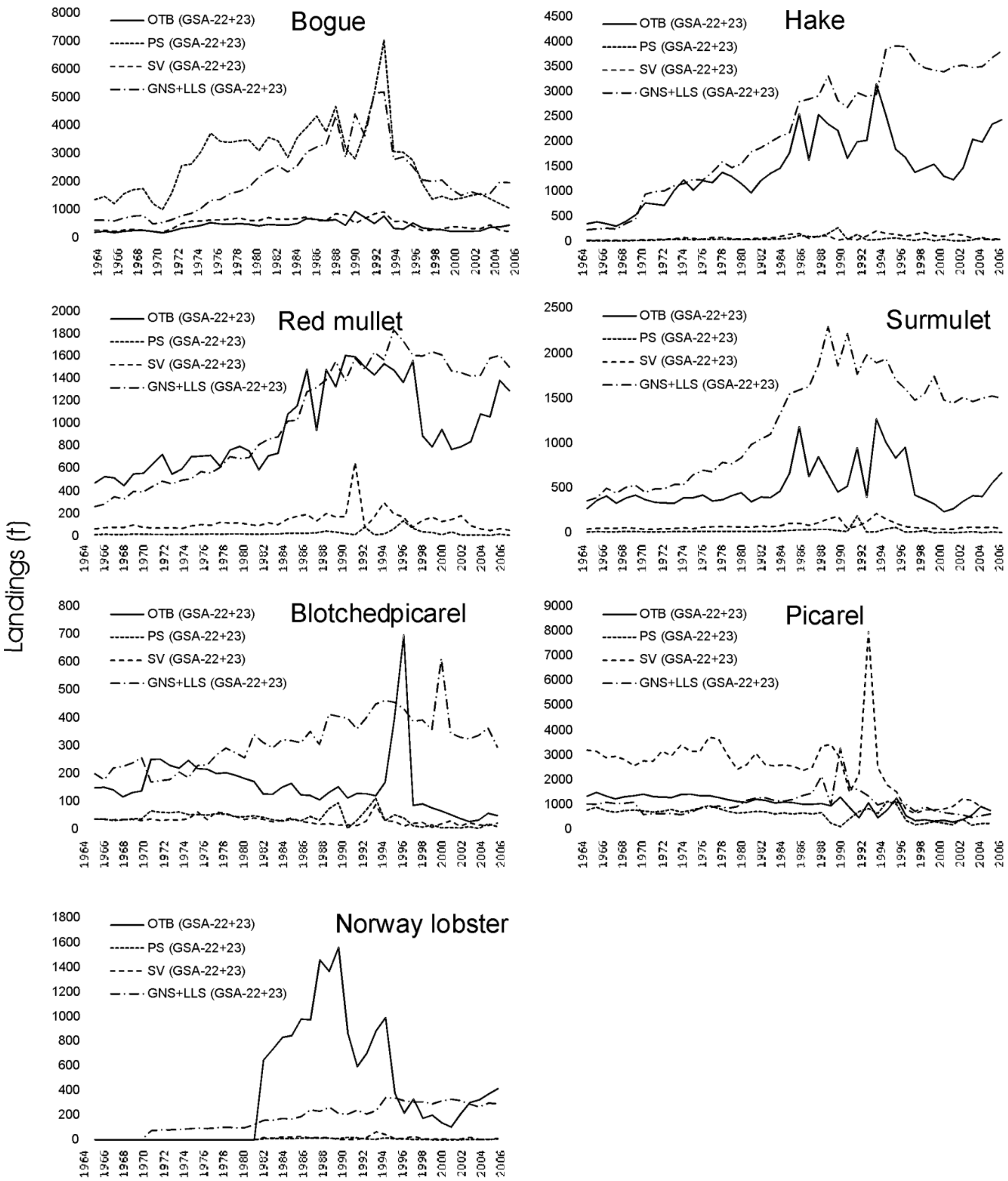


Figure 2. Annual species landings per gear (OTB, PS, SV, GNS and LLS) in GSA 22&23, 1964-2007.

*Effort*

Numbers of vessels per gear for all Greek waters show an increasing trend during 1964-1990 and a decrease thereafter for all gear types. The same pattern is also evident for the engine HP (Figure 3). Thus, horse power (HP) was considered as the most robust proxy of the effort for using in the analysis. In order, also, to incorporate the technological changes and the modernization of the fishing fleet per each gear-type during 1964-2007, standardized index of HP was done according with the following:

(a) for trawls, purse-seines, beach-seines and small-scale gears it was assumed an annual increase in fishing power of 2.73% (G.C. Osio 2012) corrected per the number of fishing days; For reasons of consistency, the value of 2.73% was used throughtout the paper for annual rate of increase for all gears, even though this estimate has been estimated only for trawlers (G.C. Osio 2012).

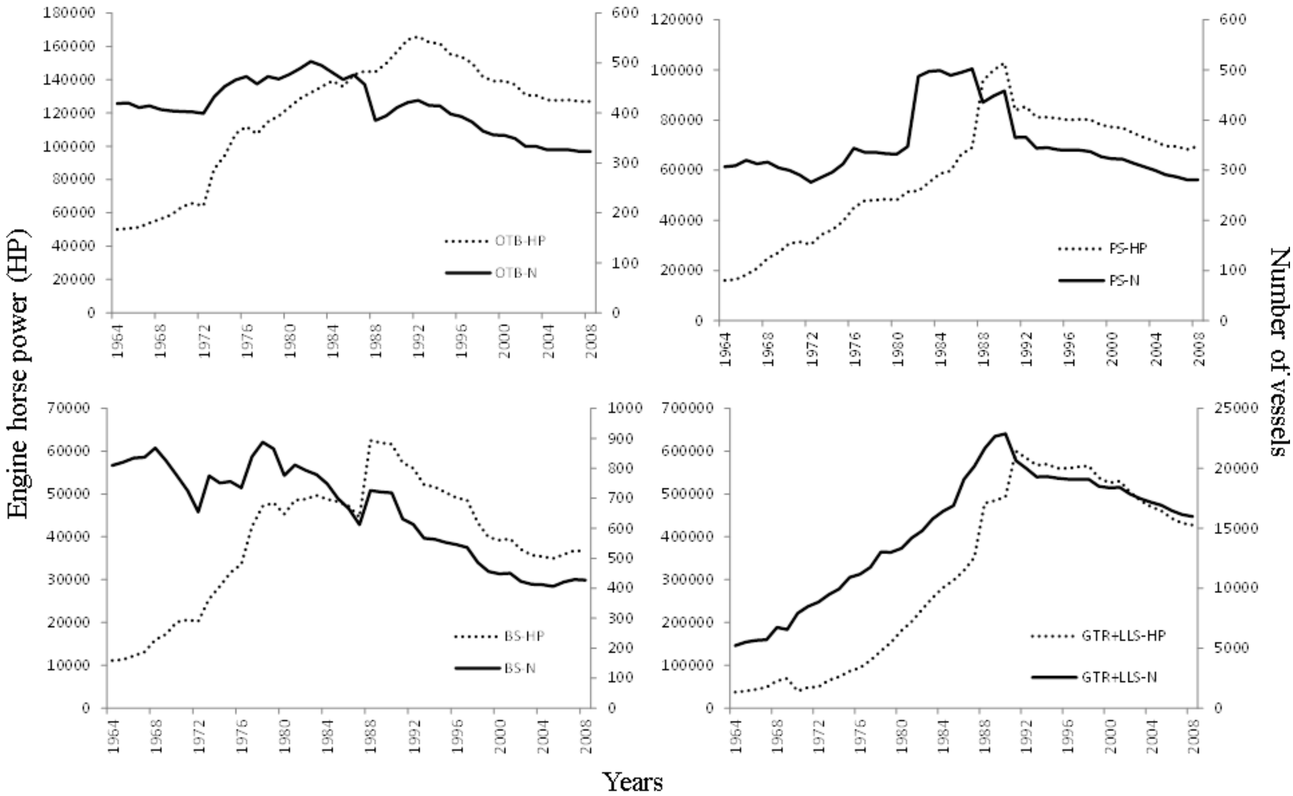


Figure 3. Number of fishing vessels (lines) and engine HP (dotted lines) per gear (OTB, PS, SV, GNS and LLS) in Greek waters of GSA 20, 22&23), 1964-2008.

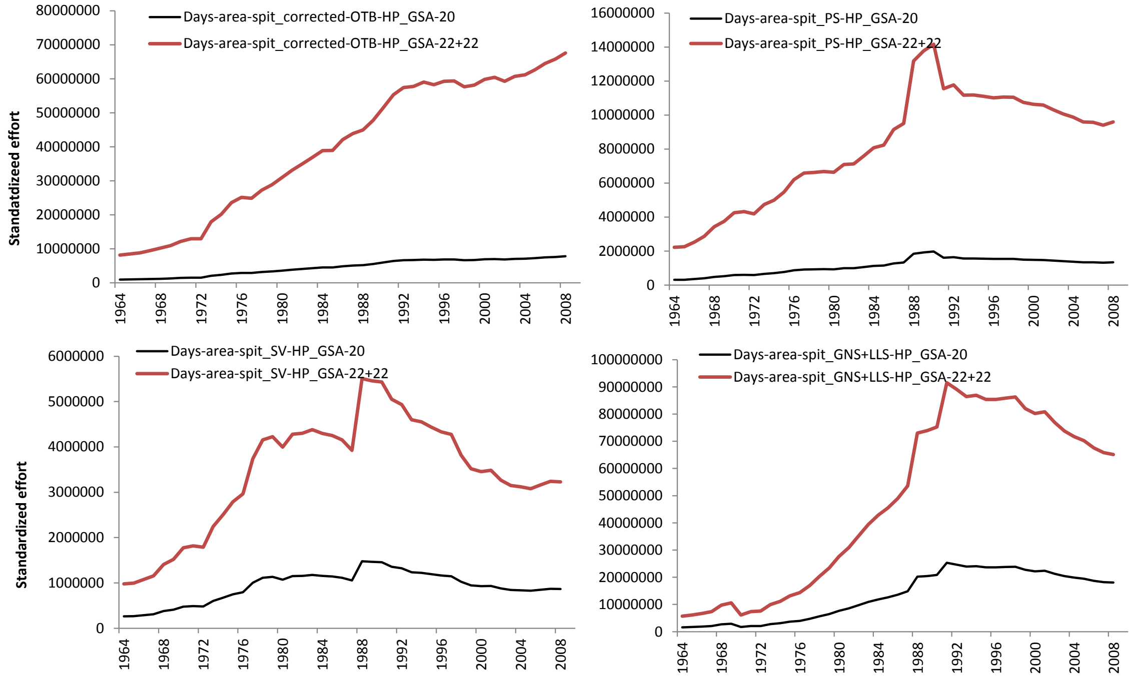

Figure 4. Standardized effort per gear (OTB, PS, SV, GNS and LLS) in GSA 20 and 22&23, 1964-2008.

Estimation of effort was based on interviews conducted with random sampling in 30 sampling stations (ports) in GSA 20. Sampling was conducted on a monthly basis at each sampling site, where a sufficient number of vessels from each fleet segment and gear type were randomly selected and effort was recorded. In addition, all fishing vessels present in the sampling stations were categorized as full-time, part-time, occasionally fishing, or inactive and the proportion of the year when they were active was estimated. Based on this information, sampled data were raised to the whole fleet to estimate total effort per fleet segment, fishing gear, and GSA. It should be noted that the estimated effort do not refer to the effective effort targeting for example hake, but to the entire effort of each fleet segment. Fishing effort data (engine horse-power values, HP) per gear for the period 1964-1990 was disaggregated by GSA (separately for 20 and 22&23 GSAs) based on the bootstrapped means of the proportions of the HP values in GSA 22&23 to total Greek areas (i.e. GSA 20, 22 and 23) for each gear separately from data derived from DCR between 1991 and 2008 according to the following Table.

| HP in GSA 22&23 / HP in GSAs 20, 22 and 23 | | |
|---|---|---|
| Fishing gear | Mean | SD |
| OTB | 0.897 | 0.00048 |
| PS | 0.873 | 0.00042 |
| SV | 0.774 | 0.00143 |
| Small-scale | 0.808 | 0.00031 |

The fishing effort in different units by fishing technique deployed in GSA 20 and GSA 22&23 during 2003-2008 are shown in Table 4.

**Table 4. Fishing effort in different fleet units by fishing gear deployed in GSA 20 and GSA 22&23, 2003-2008.**

| | GSA-20 | | | | | | GSA-22+23 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OTB_12-24 | | | OTB_24-40 | | | OTB_12-24 | | | | OTB_24-40 | |
| Years | DAYS | GT*DAYS | K*DAYS | DAYS | GT*DAYS | K*DAYS | DAYS | GT*DAYS | K*DAYS | OTB_24- | DAYS | GT*DAYS |
| 2003 | 5790 | 332071 | 1850256 | 2020 | 242373 | 524584 | 23565 | 1372119 | 7365681 | 2003 | 28971 | 3555230 |
| 2004 | 5525 | 365717 | 1950645 | 1759 | 215192 | 496870 | 23524 | 1211617 | 6606498 | 2004 | 29865 | 3760166 |
| 2005 | 5460 | 337899 | 1511041 | 818 | 97155 | 218623 | 24937 | 1318385 | 7406948 | 2005 | 31643 | 4235418 |
| 2006 | 4284 | 318017 | 1143570 | 2398 | 246994 | 881385 | 21265 | 1255520 | 6287246 | 2006 | 31567 | 4298674 |
| 2007 | | | | | | | | | | | | |
| 2008 | 6753 | 534692 | 1800736 | | | | 51855 | 5355704 | 16013057 | | | |
| | PS_12-24 | | | | | | PS_12-24 | | | | PS_24-40 | |
| 2003 | 3377 | 66113 | 454877 | | | | 41539 | 1767398 | 8709727 | 2003 | 2942 | 230726 |
| 2004 | 2604 | 54104 | 355157 | | | | 39783 | 1620847 | 8111571 | 2004 | 3989 | 366709 |
| 2005 | 4342 | 163038 | 529175 | | | | 42520 | 1753346 | 8123673 | 2005 | 5690 | 542120 |
| 2006 | 3782 | 128970 | 426087 | | | | 37255 | 1568893 | 7386042 | 2006 | 5619 | 539146 |
| 2007 | | | | | | | 31492 | 1305252 | 6511187 | | 5338 | 524544 |
| 2008 | 5197 | 155249 | 615159 | | | | 35090 | 1457212 | 6898061 | | 4938 | 473121 |
| | SV_0-12 | | | SV_12-24 | | | SV_0-12 | | | | SV_12-24 | |
| 2003 | 12337 | 65354 | 730269 | 1092 | 17745 | 132797 | 30819 | 194255 | 2001697 | 2003 | 5446 | 100640 |
| 2004 | 10011 | 50085 | 616105 | 891 | 12380 | 93360 | 27626 | 184614 | 1631559 | 2004 | 4361 | 85031 |
| 2005 | 9903 | 44421 | 478156 | 980 | 14020 | 125941 | 28991 | 191537 | 1622294 | 2005 | 4208 | 84728 |
| 2006 | 10298 | 41192 | 495000 | 1064 | 15866 | 128628 | 25644 | 165052 | 1437602 | 2006 | 4453 | 92219 |
| 2007 | | | | | | | | | | | | |
| 2008 | 12774 | 75249 | 807597 | | | | 25138 | 214985 | 1774864 | | | |
| | LLS_0-12 | | | LLS_12-24 | | | LLS_0-12 | | | | LLS_12-24 | |
| 2003 | 110427 | 389127 | 2891531 | 3733 | 46980 | 355754 | 364138 | 1399266 | 12031033 | 2003 | 16957 | 362834 |
| 2004 | 77505 | 240490 | 1201281 | 2153 | 27999 | 233822 | 275344 | 1139299 | 8572064 | 2004 | 19661 | 520964 |
| 2005 | 82803 | 183020 | 1669146 | 1357 | 20120 | 153968 | 299913 | 1206123 | 8617539 | 2005 | 15941 | 396363 |
| 2006 | 73044 | 217392 | 1381226 | 747 | 10959 | 66882 | 243748 | 1126228 | 7316212 | 2006 | 9587 | 196884 |
| 2007 | | | | | | | | | | | | |
| 2008 | 99755 | 396520 | 3486777 | | | | 302098 | 1244484 | 7914684 | | | |
| | GNS_0-12 | | | GNS_12-24 | | | GNS_0-12 | | | | GNS_12-24 | |
| 2003 | 712396 | 2815012 | 28993233 | 5376 | 70113 | 615806 | 1472463 | 5350223 | 45683313 | 2003 | 27044 | 487692 |
| 2004 | 627729 | 2453210 | 21657663 | 6811 | 95498 | 871815 | 1422802 | 5191568 | 51042532 | 2004 | 23078 | 483940 |
| 2005 | 649254 | 2519098 | 21063412 | 6529 | 92551 | 695423 | 1499848 | 5134895 | 52037822 | 2005 | 29154 | 647107 |
| 2006 | 583574 | 2125774 | 16728512 | 5277 | 84453 | 544006 | 1451404 | 4898203 | 49425754 | 2006 | 27730 | 712201 |
| 2007 | | | | | | | | | | | | |
| 2008 | 574268 | 2264227 | 18504513 | | | | 1374948 | 5309125 | 50244080 | | | |

### 1.1.5 *Considerations on data quality*

Regarding the quality of the fishing effort data, they are derived from two different sources according with the study period: (a) during 1964-1990 data were derived from HELSTAT and (b) during 1991-2007 data were derived from the Common Fisheries Register (CFR), which is the official record of technical details, characteristics and activities of all Community fishing vessels based on the national registers of the EC Member States since 1991 (EC, 1998; Ministry of Rural Development and Food, 2003). The two datasets show a considerably good agreement during 1964-2007 (Fig. 5).

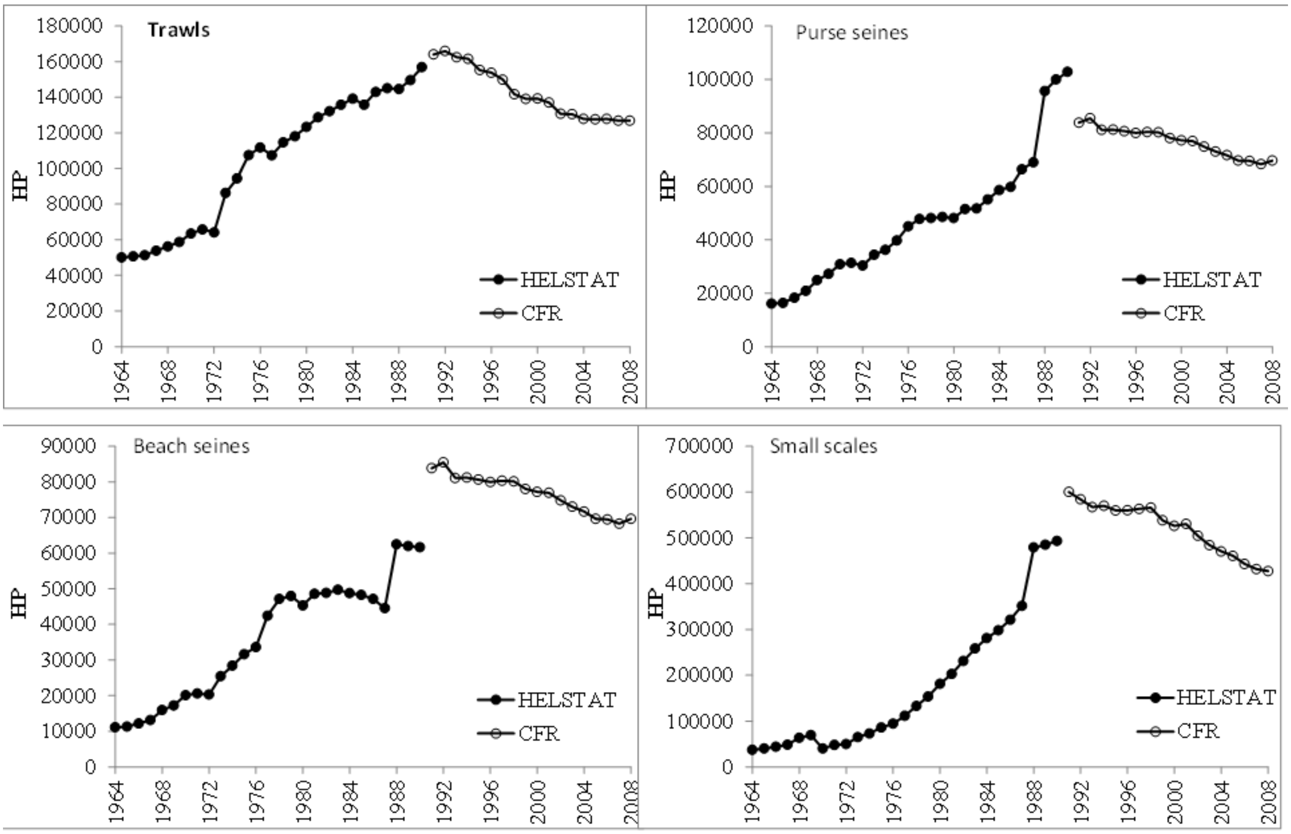

Figure 5. Engine horse-power (HP) per gear-type for the data derived from the Hellenic Statistical Authority (HELSTAT) and Common Fishery Register (CFR) during 1964-2007.

With respect to the fisheries landings, the reconstructed landings might differ from the official DCR-DCF landings depending on the species and the methodology used for estimating the landings. However, DCR-DCF data are available for a small number of years. In contrast, reconstructed landings are the longest time series available. Future corrections of the reconstructed landings (i.e. adding discards, illegal and unreported landings) as well as tuning the reconstructed landings using other sources (e.g. DCR-DCF) is underway (e.g. estimating ratios of DCR-DCF landings/national landings and back casting such rations). These differences might affect the application of the different models used for the species exhibited the largest differences in landings between the two above-mentioned data sets and could explain the lack of fit of certain ASPIC models applied.

Although unusual estimates and limitations of the official fisheries statistics have been reported elsewhere (i.e. Stergiou et al., 1997; Papaconstantinou et al., 2002; Moutopoulos, 2012), these data are the most consistent data available in terms of taxonomic, spatial and temporal resolution (Stergiou et al., 2007).

The differences between the two data sets might be attributed to the different sampling methodologies applied from each source. DCF data are based on interviews conducted with random sampling in sampling stations (ports) in Greek seas. Sampling was conducted on a monthly basis at each sampling site, where a sufficient number of vessels from each fleet segment and gear type were randomly selected and effort was recorded. However, apart from the short-term of the data series (2002-2006), DCF interviews covered a limited number of the small-scale fleet (~ 10%).

Reconstructed data were based on the aggregation of fisheries landings reported by different organizations authorized for the collection of fisheries data. HELSTAT census method based on the reporting approach by providing a questionnaire to the fishers according to which fishermen are willingness to supply with fuels with lower prices from local tax office authorities. To attain the best possible accuracy of the reported statistics, a booklet of fishing production has been also provided to each fisher which is checked by the members of the tax office authorities at the submission of the monthly statistical questionnaires.

## References

Giacomo Chato Osio, "The historical fisheries in the Mediterranean Sea: a reconstruction of trawl gear, effort and trends in demersal fish stocks", PhD Thesis, University of New Hampshire 2012

Section 2

Stock assessments

# 1.1 **Stock assessment of *Spicara flexuosa* in GSA 20**

## 1.1.1 *Stock identification and biological features*

### 1.1.1.1 Stock Identification

Blotched picarel, *Spicara flexuosa*, is a neritic species, distributed in the Eastern Atlantic (Portugal, Morocco, and Canary Islands) and the Mediterranean and Black Seas. It is a protogynous hermaphrodite species. It is common over Posidonia beds and on sand or muddy bottoms, ranging at depths 30-90m, feeding on zooplankton. Blotched picarel spawns between August and October. It is considered of low commercial value (www.fishbase.org).

### 1.1.1.2 Growth

The von Bertalanffy growth parameters used in the analyses of *Spicara flexuosa* in GSA 20 were the ones estimated by Soukan et al., (2010) for the Aegean Sea i.e. $L_{inf}$=21.99 cm, k=0.255, $t_o$=-1.16 were utilized, and similar to those used in GSA 22&23. No sex discrimination was applied.

Similarly, parameters of the length-weight relationship (combined sex) are: a= 0.0028, b = 3.505 (length in cm) based on Karakulak et al., (2006) and other studies in the Aegean Sea.

### 1.1.1.3 Maturity

The following maturity ogive was used for *Spicara flexuosa* assessments in GSA 20. Due to the lack of DCF data, the maturity ogive was estimated based on MEDITS survey length frequency distribution and the estimates of first length at reproduction i.e. 11.51 cm and 13.12 cm for females and males, respectively as estimated by Soukan et al., (2010) for the Aegean Sea.

Tab. 1.1.1.1. Maturity ogives of *Spicara flexuosa* in GSA 20.

| Age | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Prop. Mature | 0 | 0.3 | 0.95 | 1 | 1 | 1 | 1 |

## 1.1.2 *Fisheries*

### 1.1.2.1 General description of fisheries

Mediterranean landings data for blotched picarel are lacking or grouped with other *Spicara* species (*S. maena* and *S. smaris*), for which the Mediterranean landings peaked in 1994 and declined thereafeter. Turkish landings from the Aegean sea represent around 10% of the total landings of this GSA (data from FAO, FishStat).

### 1.1.2.2 Management regulations applicable in 2008 and 2009

There are not any special management regulations enforced for this species apart from the general ones applied throughout the Greek Seas.

### 1.1.2.3 Catches

***Landings***

The contribution of the *S. flexuosa* to the landings of the different gears for GSA 20 is shown below (Table 3 in section 1 of this report) in Table 1.1.2.1.

**Table 1.1.2.1. Species composition (%) per gear and study area.**

| | All gears combined | OTB | PS | SV | GNS and LLS |
|---|---|---|---|---|---|
| GSA-20 | 2.2 | 10.6 | 0.2 | 2.7 | 0.5 |

The landings of *S. flexuosa* by gear are shown in figure 1.1.2.1. The contribution of trawlers to the landings is higher than the remaining gears. Landings increased to a maximum in 2006 and declined thereafter for trawlers, whereas for the remaining gears landings increased to a maximum in mid 1990s and declined thereafter (Figure 2 in section 1 of this report).

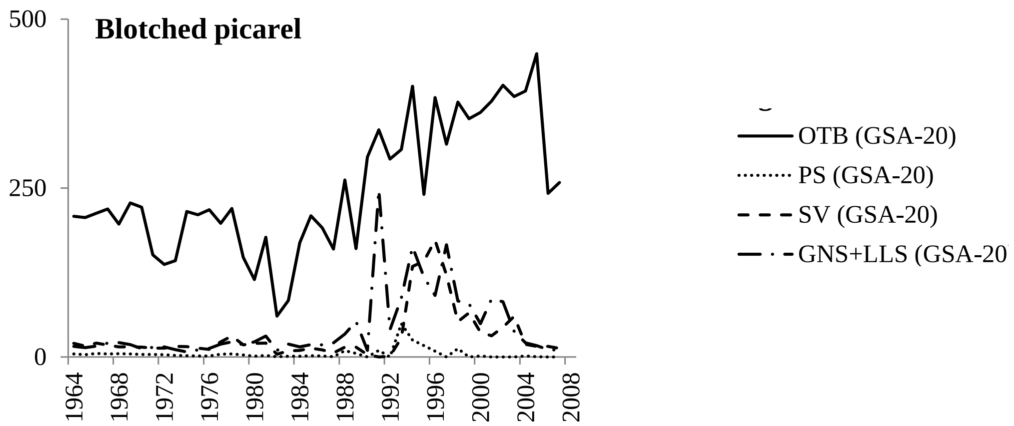


**Fig. 1.1.2.1. Landings of *S. flexuosa* in GSA 20 (Greece only) by fishing gear for the period 1964-2008.**

***Discards***

There is no available time series of discard data for this species in Greek waters. Nevertheless, discards for small-scale fisheries in GSA 20 (notably Patraikos Gulf) can be as high as 84% (Tzanatos et al., 2007).

***Fishing effort***

The fishing effort for the gears catching *S. flexuosa* in GSA 20 has been presented in section 1 of this report.

### 1.1.3 *Scientific surveys*

**MEDITS**

***Methods***

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 20 the following numbers of hauls were reported per depth stratum (Table 1.1.3.1).

**Tab. 1.1.3.1. Number of hauls per year and depth stratum in GSA 20.**

| Stratum | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2003 | 2004 | 2005 | 2006 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **010-050** | 1 | 2 | 2 | 2 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **050-100** | 3 | 4 | 8 | 7 | 11 | 10 | 11 | 9 | 10 | 10 | 10 | 9 | 10 |
| **100-200** | 1 | 3 | 4 | 2 | 5 | 6 | 5 | 6 | 6 | 6 | 5 | 6 | 6 |
| **200-500** | 2 | 3 | 4 | 4 | 7 | 7 | 7 | 8 | 8 | 9 | 8 | 8 | 7 |
| **500-800** | 1 | 2 | 4 | 3 | 5 | 5 | 5 | 5 | 5 | 3 | 5 | 4 | 6 |
| **TOTAL** | 8 | 14 | 22 | 18 | 32 | 31 | 31 | 31 | 32 | 31 | 31 | 30 | 32 |

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution and quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

***Geographical distribution patterns***

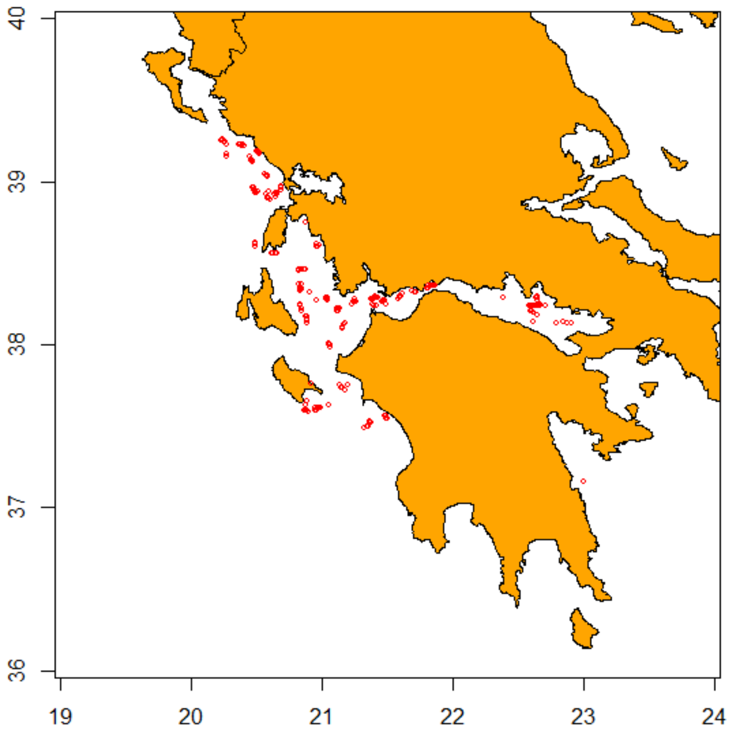


**Fig. 1.1.3.2. Distribution of sampling hauls of the MEDITS survey in GSA 20.**

***Trends in abundance and biomass***

Fishery independent information regarding the state of *Spicara flexuosa* in GSA 20 was derived from the international survey MEDITS.

The estimated abundance index exhibited an increase from 1994 up to 2006 and then declined in the last two years (Fig. 1.1.3.3).

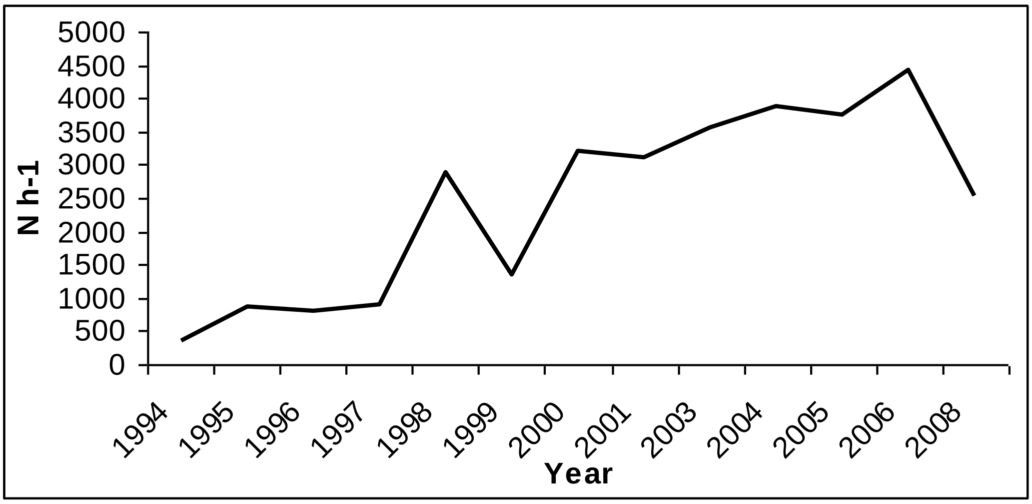


**Fig. 1.1.3.3. Abundance index of blotched picarel in GSA 20.**

***Trends in abundance by length or age***

Figure 1.1.3.4-5 displays the length frequency composition of *Spicara flexuosa* as derived from the MEDITS survey for GSA 20.

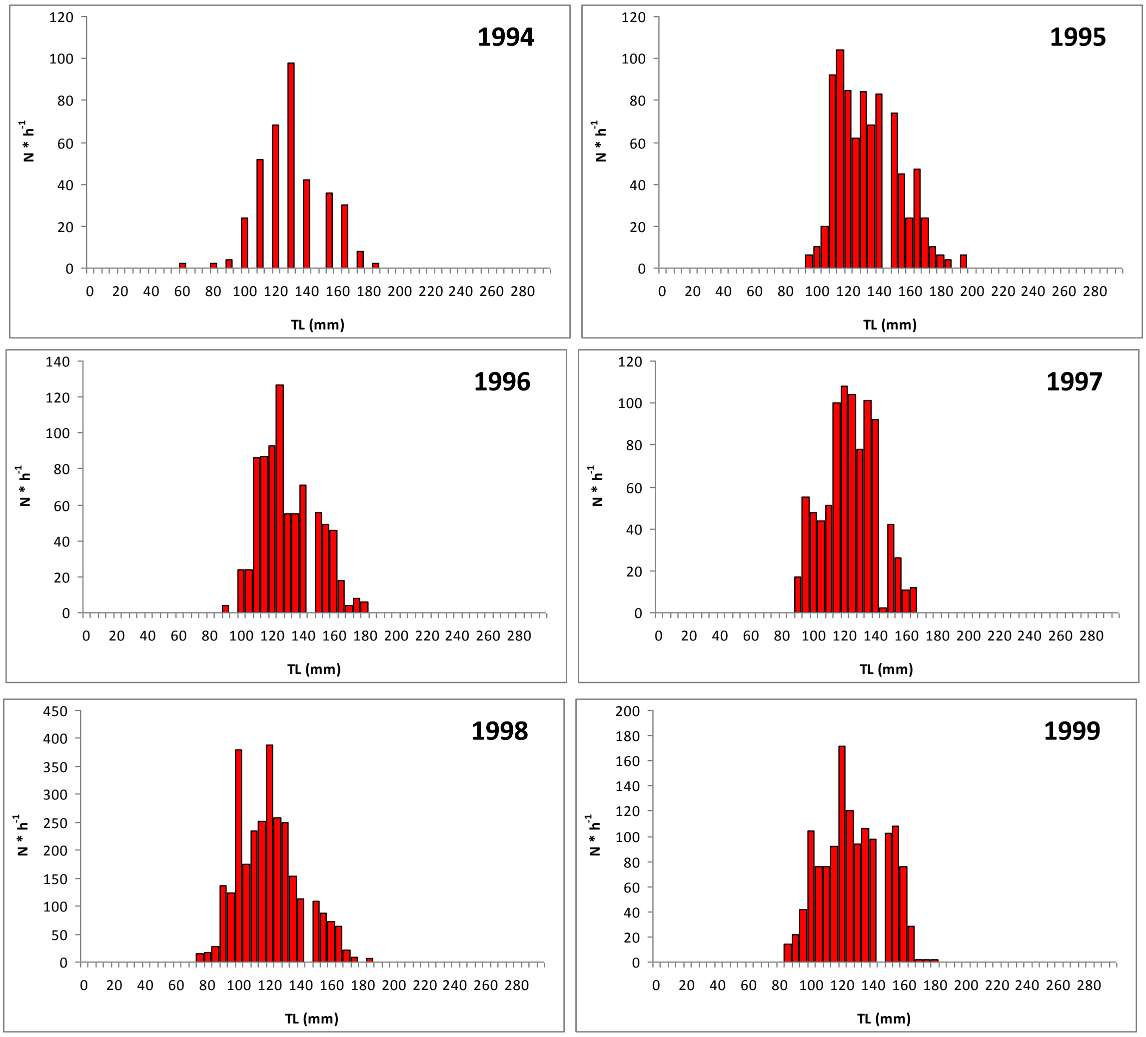

**Fig. 1.1.3.4. Stratified abundance indices by size of *Spicara flexuosa* in GSA 20, 1994-1999 based on MEDITS survey.**

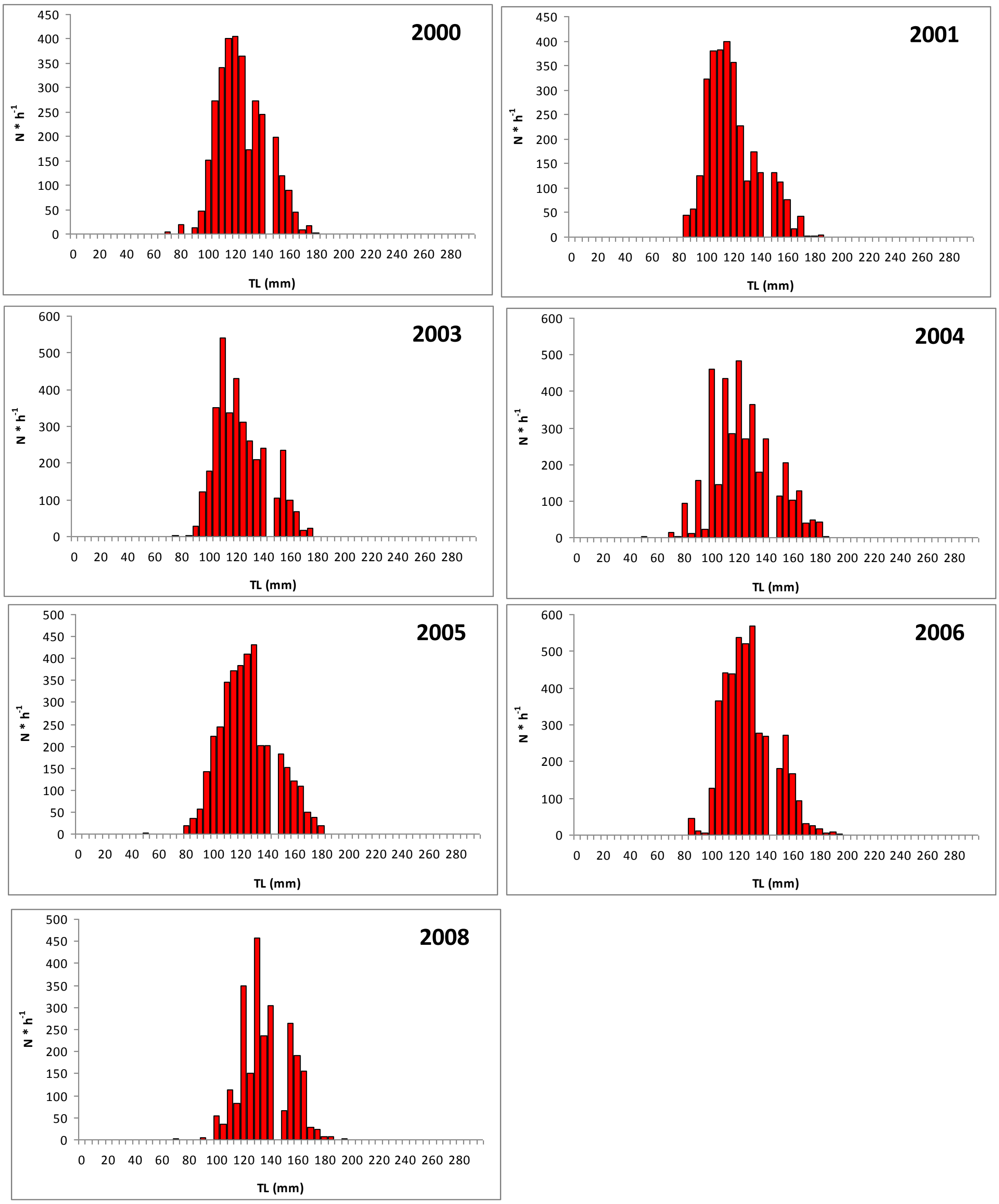


**Fig. 1.1.3.5 Stratified abundance indices by size of *Spicara flexuosa* in GSA 20, 2000-2008 based on MEDITS survey.**

### 1.1.4 *Assessment of historic stock parameters*

#### 1.1.4.1 Method 1: Stock Production Model

***Justification***

A production model has been used in order to estimate the fishing mortality and the biomass at sea and the relative reference points in term of $F_{MSY}$ and $B_{MSY}$, using the catch and effort data as estimated in section 1 of this report and by Moutopoulos and Stergiou (2012).

***Input parameters***

A non-equilibrium dynamic biomass model incorporating covariates [ASPIC 5.10.1] (Prager 2005) was applied to catch and effort (HP x Days) data from the GSAs 20, of the main fishing fleet exploiting blotched picarel (trawl). Three model shapes, namely: Logistic, Fox and the Generalized Estimate Exponent were used.

Due to the low amount of landings observed for the other fisheries, the model has been run only using trawl. Such decision provided better fit and more realistic values of $F_{MSY}$ and $B_{MSY}$, although they can be respectively slightly overestimated and underestimated.

In addition to data on catch and effort, ASPIC requires starting guesses and ranges for the parameters to be estimated by the model: carrying capacity (K), maximum sustainable yield (MSY), the ratio of the biomass at the beginning of the first year to the carrying capacity (B1/K) and catchability (q) (Table 1.1.4.1).

**Table 1.1.4.1. ASPIC input parameters of the FIT mode for GSA 20.**

| B1/K | MSY | Range of MSY | K | Range of K | Fishing fleet | q (mean (CPUE) / 2*max(Y)) |
|---|---|---|---|---|---|---|
| 0.5 | 200 | 100 – 1000 | 4500 | 3000 - 10000 | Bottom Trawl | 8.22725E-08 |

After fitting the values for the above parameters, the FIT mode is run. At this point ASPIC computes estimates of parameters, including time trajectories of fishing intensity and stock biomass. The results of the fit were used to compute bias-corrected approximate confidence limits (80% CL) through bootstrap analysis. The model fittings are under the assumption that yield in each year is known more precisely than fishing effort or relative abundance. In other words, all model fittings were conditioned on yield, rather than on effort or relative CPUE (Prager 2005).

If there is normal convergence, the point estimates of the FIT mode were loaded in the BOT mode for bootstrapping. In this mode the programme computes bootstrap confidence intervals on estimated quantities. This approach re-samples the residuals from the optimum fit to generate new bootstrap samples of the observed time series. The residuals between the observed and predicted catch rates (CPUE) are used for bootstrap analysis. Bootstrap data sets are constructed by combining predicted CPUE with a randomly chosen residual to compute a pseudo-CPUE value. The model is then refit, using the pseudo-CPUE, which is assumed to relate back to stock biomass via the catchability coefficient (CPUE = qBt). The process is repeated at least 1000 times (bootstrap trials) for each different fit. At each trial the objective function used is the sum of squared errors (Haddon 2001, Prager 2005).

***Results***

Initial runs in the ASPIC FIT gave normal convergence only for the logistic and Fox model. The observed CPUE and predicted CPUE indexes are shown in Figure 1.1.4.1 and 1.1.4.2 respectively for the logistic and Fox models. A clear decreasing trend in CPUEs is observed for all the runs.

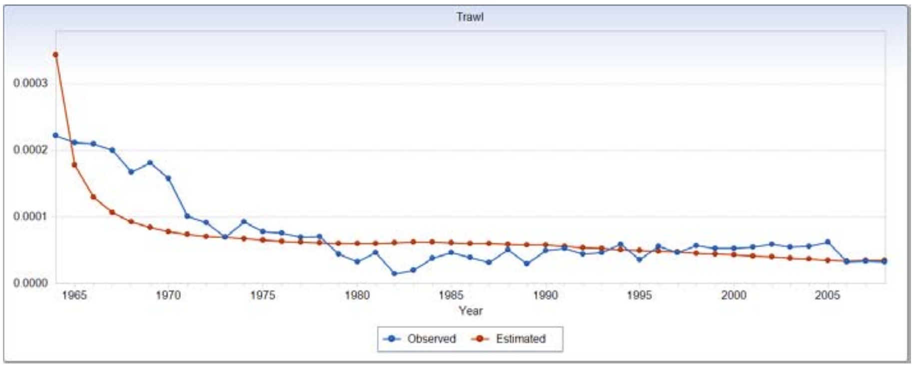


**Figure 1.1.4.1. Observed and predicted values of CPUE of blotched picarel in GSA 20 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1964-2008.**

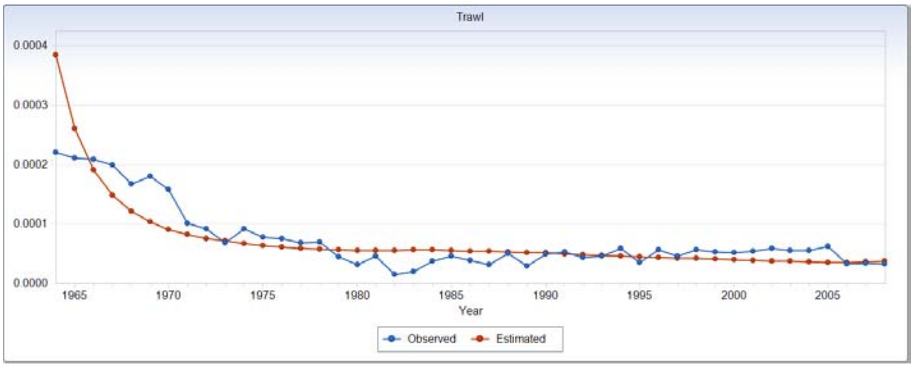


**Figure 1.1.4.2. Observed and predicted values of CPUE of blotched picarel in GSA 20 using the dynamic non-equilibrium Fox model in ASPIC for the period 1964-2008.**

In the logistic model the estimated biomass and fishing mortality fluctuated respectively from 20,000 to 2,000 t and from 0.01 to 0.2 (Figure 1.1.4.3). The biomass showed a clear decreasing trend from 1964 to 2008, while the F reached highest values in 2005. The estimated surplus production shows a general increasing trend (Figure 1.1.4.4).

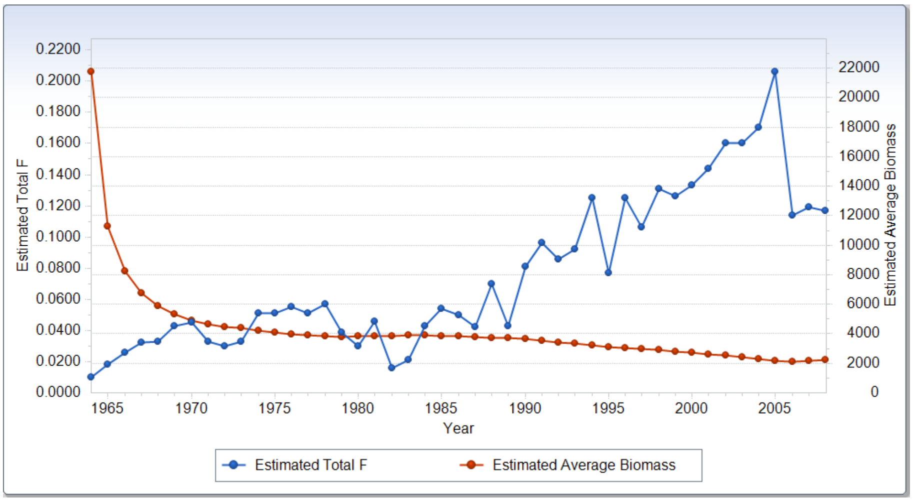


**Figure 1.1.4.3. Estimated average biomass and fishing mortality of blotched picarel in GSA 20 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1964-2008.**

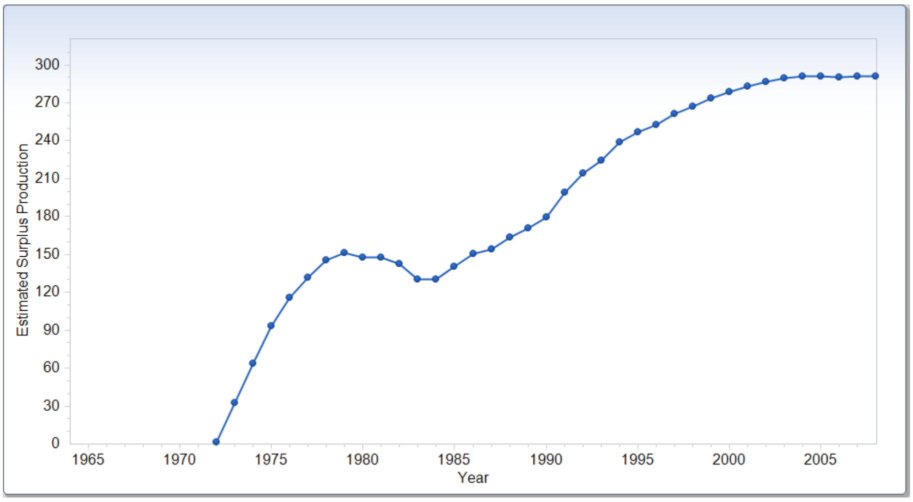


**Figure 1.1.4.4. Estimated surplus production of blotched picarel in GSA 20 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1964-2008.**

In the Fox model the estimated biomass and fishing mortality fluctuated respectively from 27,000 to 3,000 t and from 0.01 to 0.18 (Figure 1.1.4.5). The biomass showed a clear decreasing trend from 1964 to 2008, while the F reached highest values in 2005. The estimated surplus production shows a general increasing trend (Figure 1.1.4.6).

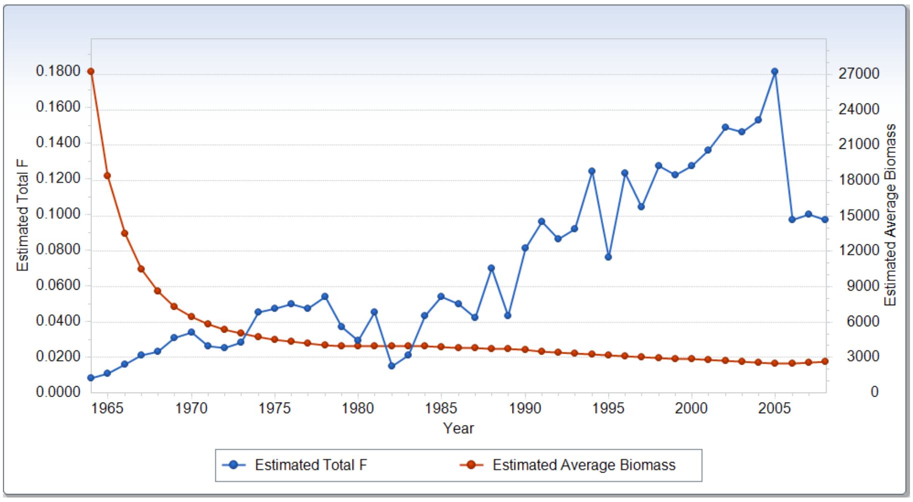


**Figure 1.1.4.5. Estimated average biomass and fishing mortality of blotched picarel in GSA 20 using the dynamic non-equilibrium Fox model in ASPIC for the period 1964-2008.**

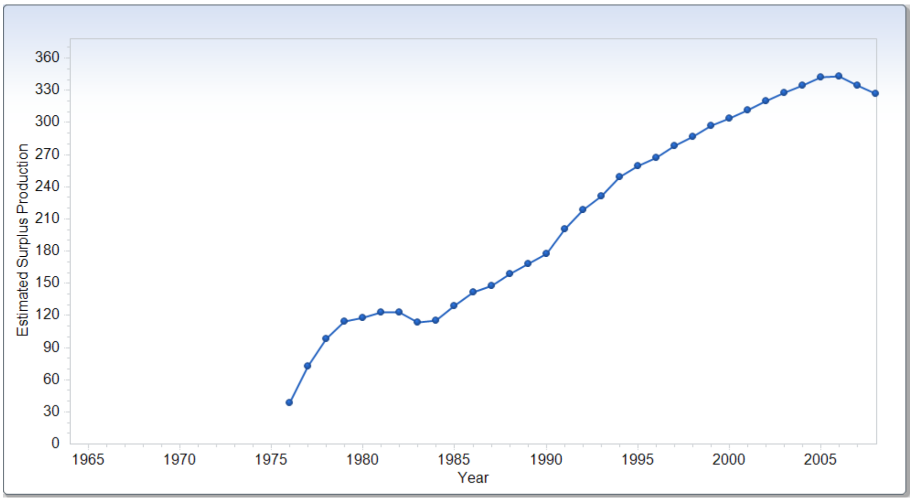


**Figure 1.1.4.6. Estimated surplus production of blotched picarel in GSA 20 using the dynamic non-equilibrium Fox model in ASPIC for the period 1964-2008.**

The goodness of fit of each model is presented in Table 1.1.4.1. The two models presented a general good fit, with the Fox model showing a better fit also in terms of contrast.

**Table 1.1.4.1. Goodness of fit results for the three model in ASPIC.**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Logistic model | Loss component number and title | Weighted SSE | N | Weighted MSE | Current weight | Inv. var. weight | R-squared in CPUE |
| | Loss(-1) SSE in yield | 0.000E+00 | | | | | |
| | Loss(0) Penalty for B1 > K | 0.000E+00 | 1 | N/A | 0.000E+00 | N/A | |
| | Loss(1) Trawl | 9.142E+00 | 45 | 2.126E-01 | 1.000E+00 | 1.000E+00 | 0.511 |
| | TOTAL OBJECTIVE FUNCTION, MSE, RMSE: | 9.14228754E+00 | | 2.177E-01 | 4.666E-01 | | |
| | Estimated contrast index (ideal = 1.0): | 8.0104 | | C* = (Bmax-Bmin)/K | | | |
| | Estimated nearness index (ideal = 1.0): | 1.0000 | | N* = 1 - \|min(B-Bmsy)\|/K | | | |
| Fox model | Loss component number and title | Weighted SSE | N | Weighted MSE | Current weight | Inv. var. weight | R-squared in CPUE |
| | Loss(-1) SSE in yield | 0.000E+00 | | | | | |
| | Loss(0) Penalty for B1 > K | 0.000E+00 | 1 | N/A | 0.000E+00 | N/A | |
| | Loss(1) Trawl | 7.019E+00 | 45 | 1.632E-01 | 1.000E+00 | 1.000E+00 | 0.588 |
| | TOTAL OBJECTIVE FUNCTION, MSE, RMSE: | 7.01935797E+00 | | 1.671E-01 | 4.088E-01 | | |
| | Estimated contrast index (ideal = 1.0): | 6.9908 | | C* = (Bmax-Bmin)/K | | | |
| | Estimated nearness index (ideal = 1.0): | 0.8259 | | N* = 1 - \|min(B-Bmsy)\|/K | | | |

**Table 1.1.4.2. Estimated parameters of blotched picarel in GSA 20.**

| Model | MSY (tons) | $B_{MSY}$ (tons) | $F_{MSY}$ | $f_{MSY}$ Trawl |
|---|---|---|---|---|
| Logistic | 291 | 2250 | 0.129 | 8.198E+06 |
| Fox | 385 | 1655 | 0.233 | 1.643E+07 |

The estimates of MSY and $F_{MSY}$ ranges after bootstrapping using approximate 80% upper and lower confidence limits are shown in Tables 1.1.4.2-3.

**Table 1.1.4.3. Estimates of MSY and $F_{MSY}$ from bootstrapped analysis in ASPIC with confidence limits.**

| Model | | MSY | | | $F_{MSY}$ | |
|---|---|---|---|---|---|---|
| | 80% lower | | 80% higher | 80% lower | | 80% higher |
| Logistic | 251 | 291 | 345 | 0.115 | 0.129 | 0.153 |
| Fox | 324 | 385 | 488 | 0.196 | 0.233 | 0.295 |

The relative biomass ($B/B_{MSY}$) and fishing mortality ($F/F_{MSY}$) are showed in Figure 1.1.4.7 for the two models.

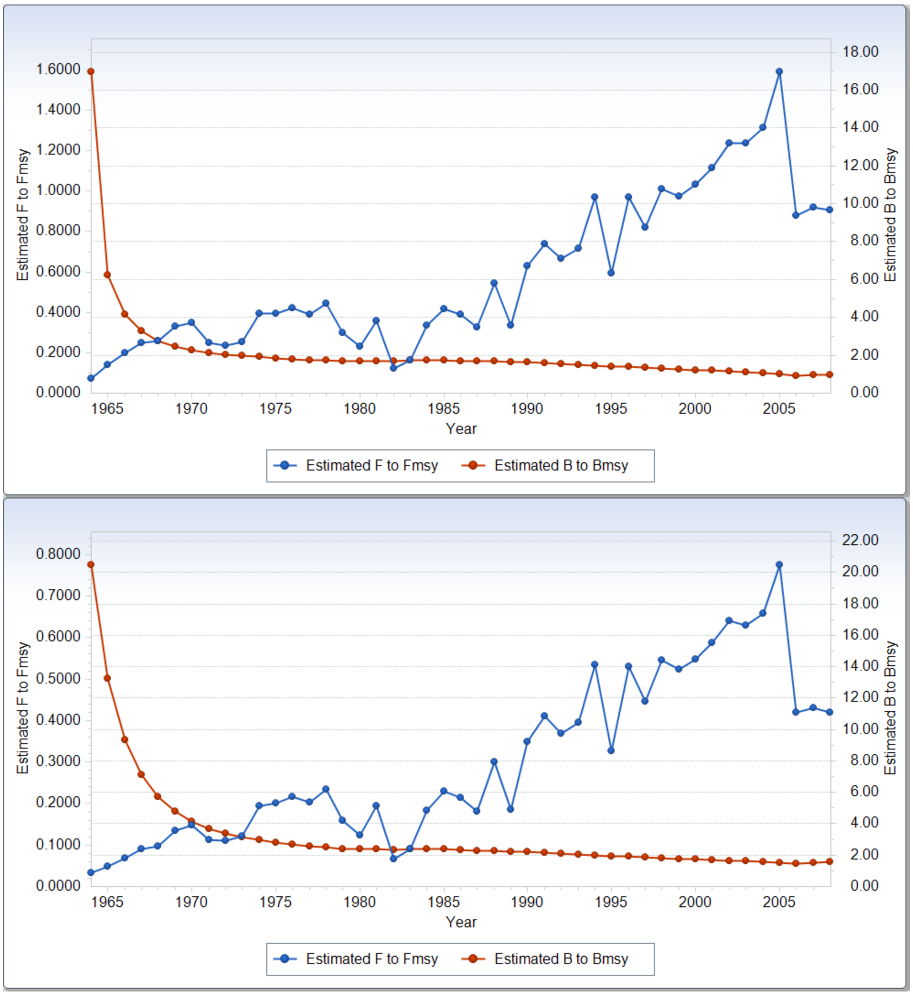


**Figure 1.1.4.7. Historic trend in estimated fishing mortality as $F/F_{MSY}$ ratio and biomass as $B/B_{MSY}$ ratio from Logistic (upper graph), Fox (lower graphs) models.**

The results of the production models suggest that blotched picarel in the GSA 20 is sustainably exploited, considering that the current F is below the $F_{MSY}$ in both models ($F/F_{MSY}$ = 0.42 from the

Fox model). The biomass at sea, although the evident decline, is around 50% higher than the $B_{msy}$ ($B/B_{MSY}$ = 1.58 from the Fox model).

### 1.1.4.2 Method 2: SURBA

***Justification***

The relatively long time series of data available from the MEDITS surveys provided the most useful data sets for the analysis. The survey-based stock assessment approach SURBA (Needle, 2003) was used on MEDITS (1994-2009) data for *Spicara flexuos* caught in GSAs 20. Length was converted to ages based on the growth equation presented in 1.1.1.2 (Soykan et al., 2010). Age groups 0 to 7 were identified. However, age group 0 was considered largely under-sampled and ages 4 to 7 were merged as a plus group. Thus ages 1 to 4+ were used for the analysis. Mean weight at age was a weighted mean based on the length frequency distribution of each age class. For years 2002 and 2007 where no survey took place and no length frequency was available the mean values of the adjacent years was used. Natural mortality was estimated as a vector for each age group based on ProdBiom (Abella et al., 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. $F_{ref}$ was set for ages 1 to 3. Young ages of *Spicara flexuosa* exhibit a very coastal distribution that MEDITS survey is unsuitable to capture. Thus a catchability pattern was defined, assuming catchability *q* equal to 0.25 (highly under-sampled) and 0.7 for ages 1 and 2 and 1 for age 3 and 4+.

***Input parameters***

**Table 1.1.4.4. SURBA Input parameters; number at age.**

| **Survey indexes (N/h)** | Age 1 | Age 2 | Age 3 | Age 4+ |
|---|---|---|---|---|
| 1994 | 0.288 | 0.28 | 0.132 | 0.016 |
| 1995 | 0.520525 | 0.487685 | 0.311987 | 0.055829 |
| 1996 | 0.358857 | 0.352 | 0.193143 | 0.013714 |
| 1997 | 0.597059 | 0.554412 | 0.133824 | 0.001471 |
| 1998 | 1.217255 | 0.607059 | 0.260392 | 0.023529 |
| 1999 | 0.458776 | 0.341224 | 0.256327 | 0.003265 |
| 2000 | 1.274016 | 0.831496 | 0.355906 | 0.020472 |
| 2001 | 1.529138 | 0.50272 | 0.263403 | 0.034188 |
| 2002 | -99 | -99 | -99 | -99 |
| 2003 | 1.467416 | 0.765543 | 0.380524 | 0.031461 |
| 2004 | 1.482591 | 0.875304 | 0.446154 | 0.070445 |
| 2005 | 1.356295 | 0.985748 | 0.446556 | 0.069675 |
| 2006 | 1.546774 | 1.319355 | 0.574194 | 0.046774 |
| 2007 | -99 | -99 | -99 | -99 |
| 2008 | 0.470762 | 0.849741 | 0.50185 | 0.03775 |

Not available data due to the lack of survey are indicated as -99.

**Table 1.1.4.5. Weight at age in the stock (in kg) of *Spicara flexuosa* in GSA 20 for 1994-2008.**

| | Age 1 | Age 2 | Age 3 | Age 4+ |
|---|---|---|---|---|
| 1994 | 0.00952 | 0.01580 | 0.02146 | 0.02146 |
| 1995 | 0.01105 | 0.01725 | 0.02146 | 0.03082 |

| | | | | |
|---|---|---|---|---|
| 1996 | 0.01053 | 0.01690 | 0.02146 | 0.02696 |
| 1997 | 0.01084 | 0.01652 | 0.02116 | 0.02696 |
| 1998 | 0.01028 | 0.01726 | 0.02146 | 0.02696 |
| 1999 | 0.01063 | 0.01686 | 0.02146 | 0.02696 |
| 2000 | 0.01071 | 0.01693 | 0.02146 | 0.02696 |
| 2001 | 0.01031 | 0.01651 | 0.02146 | 0.03082 |
| 2002 | 0.01009 | 0.01631 | 0.02116 | 0.02696 |
| 2003 | 0.01059 | 0.01743 | 0.02146 | 0.02696 |
| 2004 | 0.00861 | 0.01468 | 0.02030 | 0.02585 |
| 2005 | 0.00793 | 0.01325 | 0.02012 | 0.02696 |
| 2006 | 0.01052 | 0.01726 | 0.02146 | 0.02696 |
| 2007 | 0.01009 | 0.01631 | 0.02116 | 0.02696 |
| 2008 | 0.00970 | 0.01532 | 0.02040 | 0.02585 |

Growth parameters (Soykan et al., 2010)

| $L_\infty$ | k | $t_0$ |
|---|---|---|
| 21.99 cm | 0.255 $y^{-1}$ | -1.16 y |

| Length-weight relationships (Karakulak et al., 2006) | |
|---|---|
| a | b |
| 0.0028 | 3.505 |

| Maturity at Age (Based on GSA 25 estimates) | | | |
|---|---|---|---|
| Age 1 | Age 2 | Age 3 | Mean Age 4+ |
| 0.3 | 0.95 | 1 | 1 |

| Natural mortality (M) | | | |
|---|---|---|---|
| Age 1 | Age 2 | Age 3 | Mean Age 4+ |
| 0.83 | 0.69 | 0.63 | 0.58 |

***Results including sensitivity analyses***

The residual plots of log catchabilities show no apparent trend or pattern (Figure 1.1.4.8.).

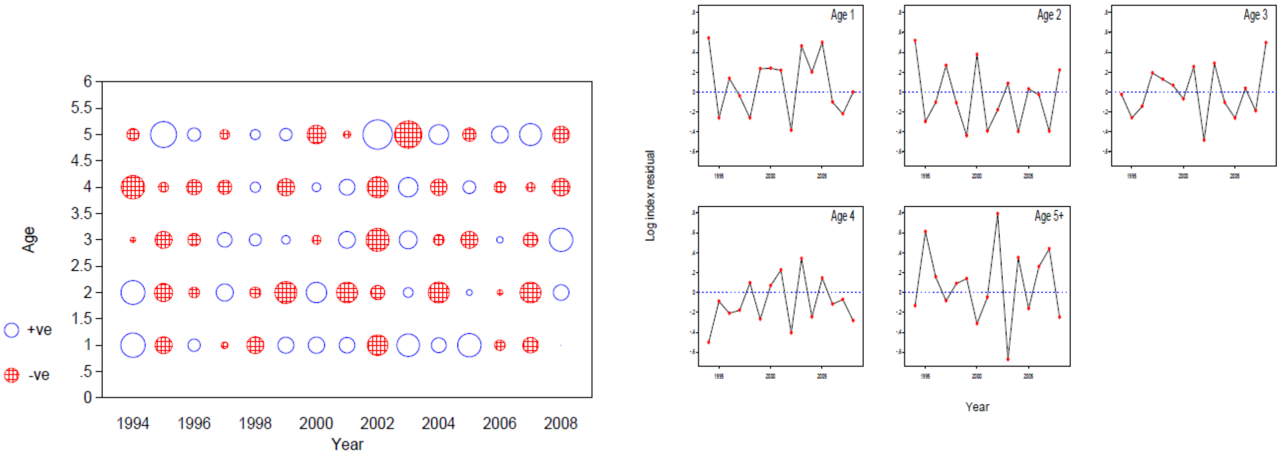


**Fig. 1.1.4.8. SURBA model: Residual plot of log index catchabilities per age and year of *Spicara flexuosa* in GSA 20 (1994-2008).**

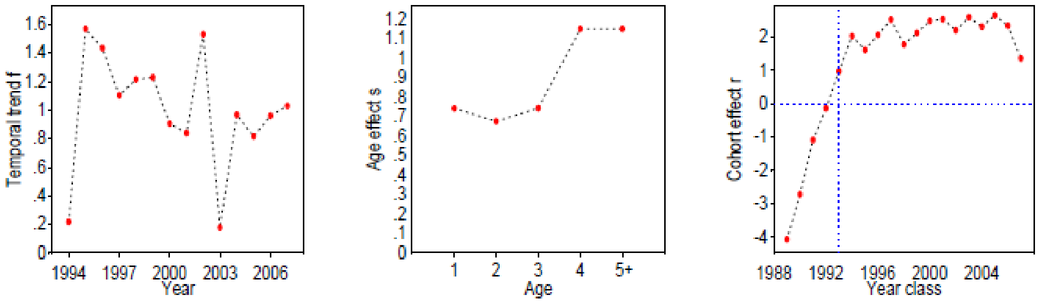


**Fig. 1.1.4.9. MEDITS survey. Fitted year, age and cohort effects for *Spicara flexuosa* in GSA 20 estimated by SURBA.**

Fitted year effect, that is the model proxy for the combination of fishing effort and mean natural mortality in the underlying population, is highly variable not presenting a specific trend. Fitted age effect shows an increase from age 3 to age 4+, while fitted cohort effect shows no apparent trend (Figure 1.1.4.9).

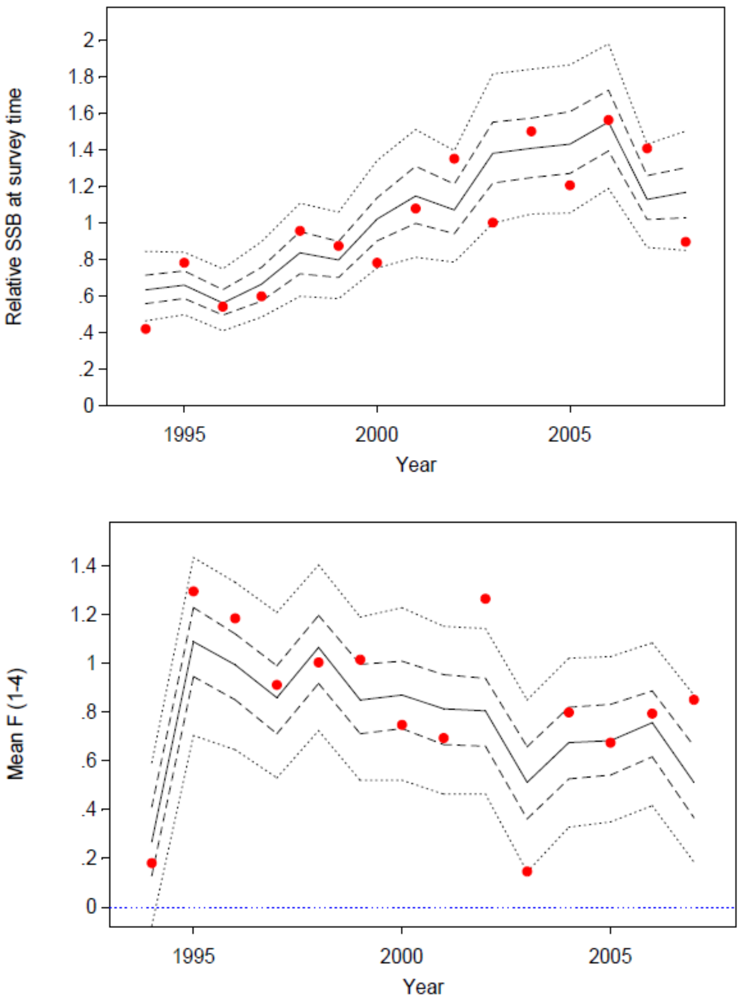


**Fig. 1.1.4.10 MEDITS survey. Estimated trend in F and relative SSB using SURBA. 50th percentile of bootstrapped runs (solid line) and 5% and 95% percentiles of bootsrapped runs (dashed lines).**

The model estimates no apparent trend in the mean F, being around 0.8. A small increase in relative SSB is observed up to 2006 with a fall afterwards.
Model diagnostics are shown in the following Figure 1.1.4.11 indicating a reliable model fit. Retrospective analysis was applied in the SURBA model for the period 1994-2008 with 8 years backward analysis. Results are presented in Figure 1.1.4.12 showing no particular retrospective bias. The assessment is generally considered reliable.

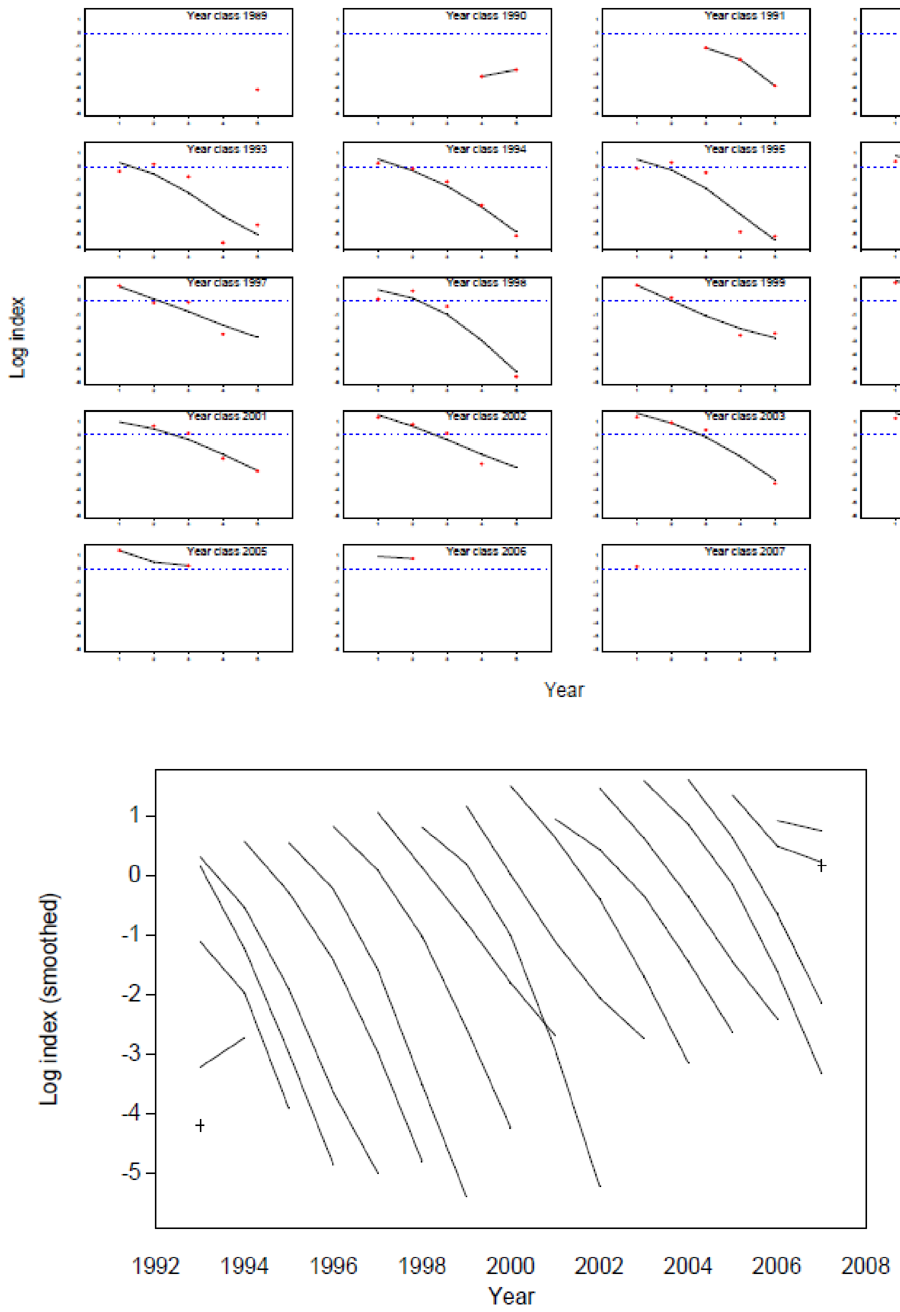


**Fig. 1.4.4.11. Model diagnostics for *Spicara flexuosa* SURBA model in the GSA 20 (MEDITS data). Top: Comparison between observed (points) and fitted (lines) survey abundance indices, for each year. Bottom: Log survey abundance indices by cohort. Each line represents the log index abundance of a particular cohort throughout its life.**

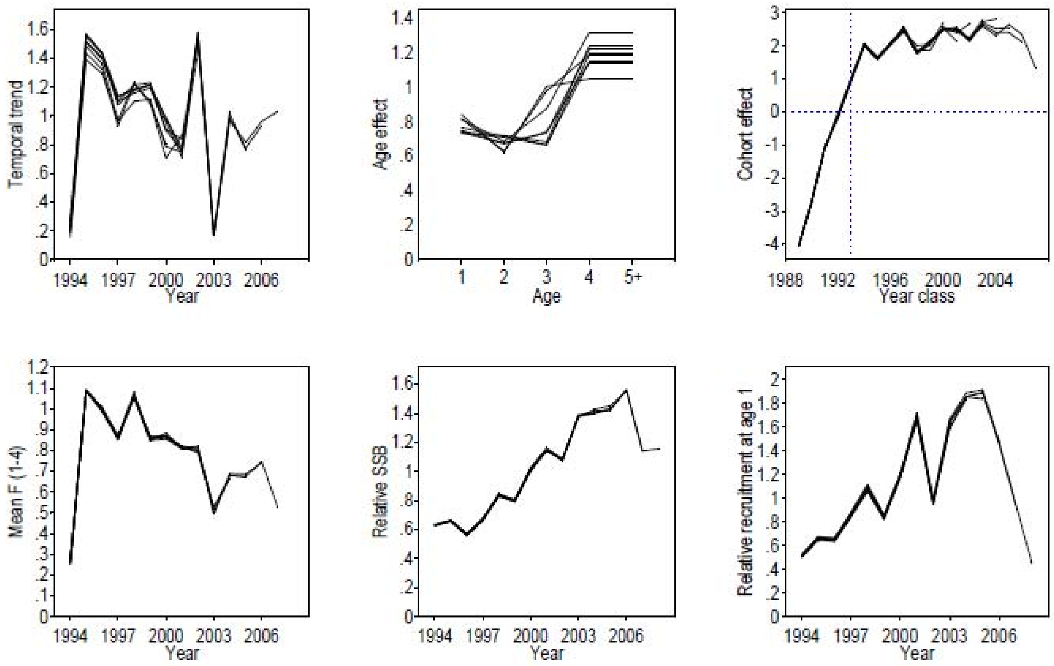


**Fig. 1.1.4.12. Model diagnostics for *Spicara flexuosa* SURBA model in the GSA 20 (MEDITS data). Results of retrospective analysis with 8 years period.**

### 1.1.5 *Long term prediction*

#### 1.1.5.1 Justification

Long-term prediction was not conducted.

### 1.1.6 *Data quality*

Survey data are derived from MEDITS surveys, which end in 2008. Data for the Surplus Production Models were derived from a reconstructed series back to 1964. However, no discard time series are available, so discards, which for blotched picarel can be very high, were not taken into account. The same is also true of illegal and unreported landings as well as subsistence landings. Since the vast majority of blotched picarel landings in GSA 20 are caught with trawlers, its landings, and thus assessments, might be affected by the landings of the fleets from neighboring countries (e.g. Albania), although this is probably not likely to occur as this species does not present extended migrations.

### 1.1.7 *Scientific advice*

#### 1.1.7.1 Short term considerations

***State of the spawning stock size***

The results of the short time series of data do not allow concluding on reference points of $B_{lim}$ or $B_{pa}$. In the absence of proposed or agreed references, STECF-Ad-hoc working group on the assessment of some Greek stocks is unable to fully evaluate the state of the stock and provide scientific advice.

The results of the production models suggest that the biomass at sea is around 50% higher than the $B_{MSY}$ ($B/B_{MSY}$ = 1.58 from the Fox model).

Based on SURBA results an increase in the SSB is observed up to 2006 with a fall afterwards. The lack of data after 2008 prevents the verification of the model output. No absolute estimates are possible since SURBA output is a relative index of SSB.

***State of recruitment***

SURBA model results showed an increase in recruitment up to 2003 and a decrease since then up to 2008. No absolute estimates are possible since SURBA output is a relative index of recruitment.

***State of exploitation***

Based on SURBA results, the mean fishing mortality (averaged over ages 1 to 3) shows no apparent trend being on average around 0.8 for the studied period. It is important to notice that SURBA provide useful information on the trend of F and not on its absolute value, as long as it is not possible to verify if selection at age of the MEDITS is comparable with these of the commercial gears. However, considering that SSB increases, STECF-Ad-hoc working group on the assessment of some Greek stocks concludes that the current level of exploitation is not detrimental to the stock.

The results of the production models suggest that blotched picarel in the GSA 20 is sustainably exploited, considering that the current F is below the $F_{MSY}$ in both models ($F/F_{MSY}$ = 0.42 from the fox model). The biomass at sea, although declining, is around 50% higher than the $B_{msy}$.

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## 1.2 Stock assessment of *Spicara flexuosa* in GSA 22&23

### 1.2.1 *Stock identification and biological features*

#### 1.2.1.1 Stock Identification

Blotched picarel, *Spicara flexuosa*, is a neritic species, distributed in the Eastern Atlantic (Portugal, Morocco, and Canary Islands) and the Mediterranean and Black Seas. It is a protogynous hermaphrodite species. It is common over Posidonia beds and on sand or muddy bottoms, ranging at depths 30-90m, feeding on zooplankton. Blotched picarel spawns between August and October. It is considered of low commercial value (www.fishbase.org).

#### 1.2.1.2 Growth

The von Bertalanffy growth parameters used in the analyses of *Spicara flexuosa* in GSA 20 were the ones estimated by Soukan et al., (2010) for the Aegean Sea i.e. $L_{inf}$=21.99 cm, k=0.255, to=-1.16 were utilized. No sex discrimination was applied.

Similarly, parameters of the length-weight relationship (combined sex) are: a= 0.0028, b = 3.505 (length in cm) based on Karakulak et al., (2006) and other studies in the Aegean Sea.

#### 1.2.1.3 Maturity

The following maturity ogive was used for *Spicara flexuosa* assessments in GSA 22&23. Due to the lack of DCF data, the maturity ogive was estimated based on MEDITS survey length frequency distribution and the estimates of first length at reproduction i.e. 11.51 cm and 13.12 cm for females and males, respectively as estimated by Soukan et al., (2010) for the Aegean Sea.

**Tab. 1.2.1.1 Maturity ogives of *Spicara flexuosa* in GSA 22&23.**

| Age | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Prop. Mature | 0 | 0.3 | 0.95 | 1 | 1 | 1 | 1 |

### 1.2.2 *Fisheries*

#### 1.2.2.1 General description of fisheries

Data on Meditteranean landings for blotched picarel are lacking or grouped with other *Spicara* species (*S. maena* and *S. smaris*), for which the Mediterranean landings peaked in 1994 and declined thereafeter. Turkish landings from the Aegean sea represents around 10% of the total lamdings of GSA 22&23 (data from FAO, FishStat).

### 1.2.2.2 Management regulations applicable in 2008 and 2009

There are not any special management regulations enforced for this species apart from the general ones applied throughout the Greek Seas.

### 1.2.2.3 Catches

***Landings***

The contribution of blotched picarel to the landings of the different gears for GSA 22&23 is shown below (see Table 3 in section 1 of this report).

| | All gears combined | OTB | PS | SV | GNS and LLS |
|---|---|---|---|---|---|
| GSA 22&23 | 0.6 | 1.0 | 0.1 | 0.5 | 0.7 |

The landings by gear are shown below. The contribution of small scale vessels (GNS and LLS) to the landings is higher than those of the remaining gears. Landings increased to a maximum in mid to late 1990s and declined thereafter (taken from Figure 2 in section 1 of this report).

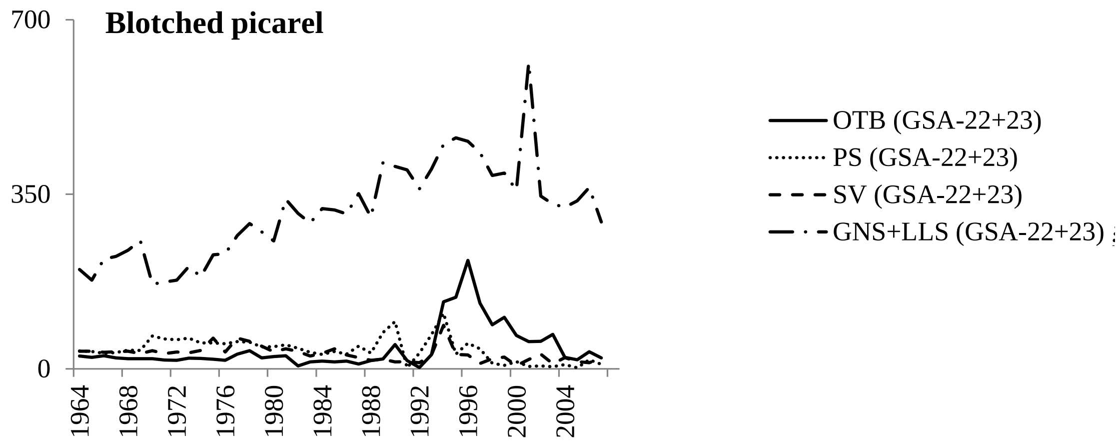


**Fig. 1.2.2.3.1. Landings of S. flexuosa in GSA 22&23 (only Greece) by fishing gear for the period 1964-2008.**

***Discards***

There is no available time series of discard for this species in Greek waters. Nevertheless, discards of the small-scale fisheries in GSA 20 (Patraikos Gulf) can be as high as 84% (Tzanatos et al., 2007).

***Fishing effort***

The fishing effort for the gears catching *S. flexuosa* in GSA 22&23 has been presented in section 1 of this report.

1.2.3 *Scientific surveys*

MEDITS

***Methods***

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 22-23 the following numbers of hauls were reported per depth stratum (Tab. 1.2.3.1).

**Tab. 1.2.3.1. Number of hauls per year and depth stratum in GSA 22&23.**

| Stratum | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2003 | 2004 | 2005 | 2006 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **010-050** | 10 | 10 | 11 | 10 | 13 | 12 | 12 | 13 | 13 | 13 | 14 | 12 | 13 |
| **050-100** | 17 | 21 | 22 | 28 | 23 | 26 | 22 | 25 | 25 | 23 | 24 | 26 | 26 |
| **100-200** | 19 | 25 | 37 | 36 | 37 | 33 | 37 | 35 | 36 | 43 | 41 | 41 | 40 |
| **200-500** | 28 | 35 | 44 | 50 | 51 | 51 | 50 | 48 | 51 | 52 | 52 | 52 | 52 |
| **500-800** | 18 | 12 | 19 | 21 | 22 | 21 | 20 | 17 | 17 | 16 | 17 | 16 | 17 |
| **TOTAL** | 92 | 103 | 133 | 145 | 146 | 143 | 141 | 138 | 142 | 147 | 148 | 147 | 148 |

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma\ (Yi*Ai) / A$$

$$V(Yst) = \Sigma\ (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution and quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. 2004).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

***Geographical distribution patterns***

Figure 1.2.3.1. provides the distribution of sampling hauls of the MEDITS survey in GSA 22&23.

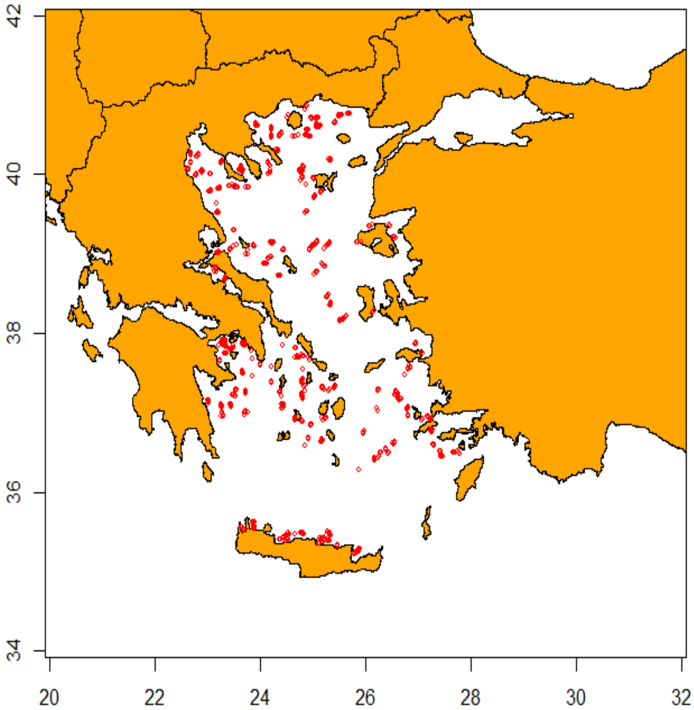


**Fig. 1.2.3.1. Distribution of sampling hauls of the MEDITS survey in GSA 22&23.**

***Trends in abundance and biomass***

Fishery independent information regarding abundance of blotched picarel in GSA 22&23 was derived from the international survey MEDITS.

The estimated abundance index exhibited an increase from 1994 up to 2004 and then declined in 2005 and 2006 and increased again (Figure 1.2.3.2).

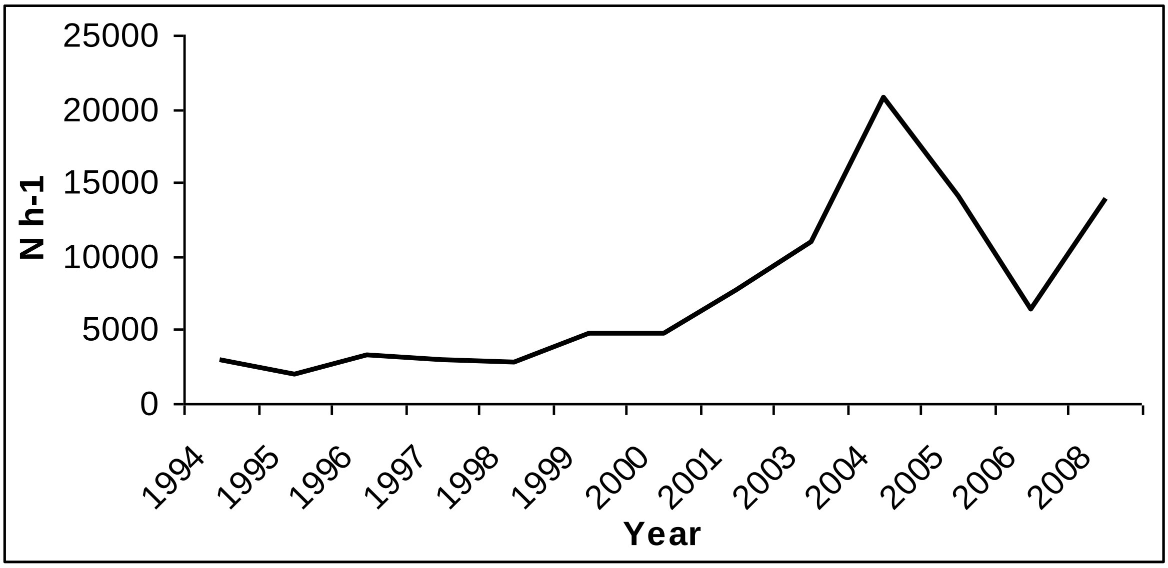


**Fig. 1.2.3.2 Abundance of Spicara flexuosa in GSA 22&23 based on MEDITS surveys**

***Trends in abundance by length or age***

Figure 1.2.3.3-4 displays the length frequency composition of *Spicara flexuosa* as derived from the MEDITS survey for GSA 22&23.

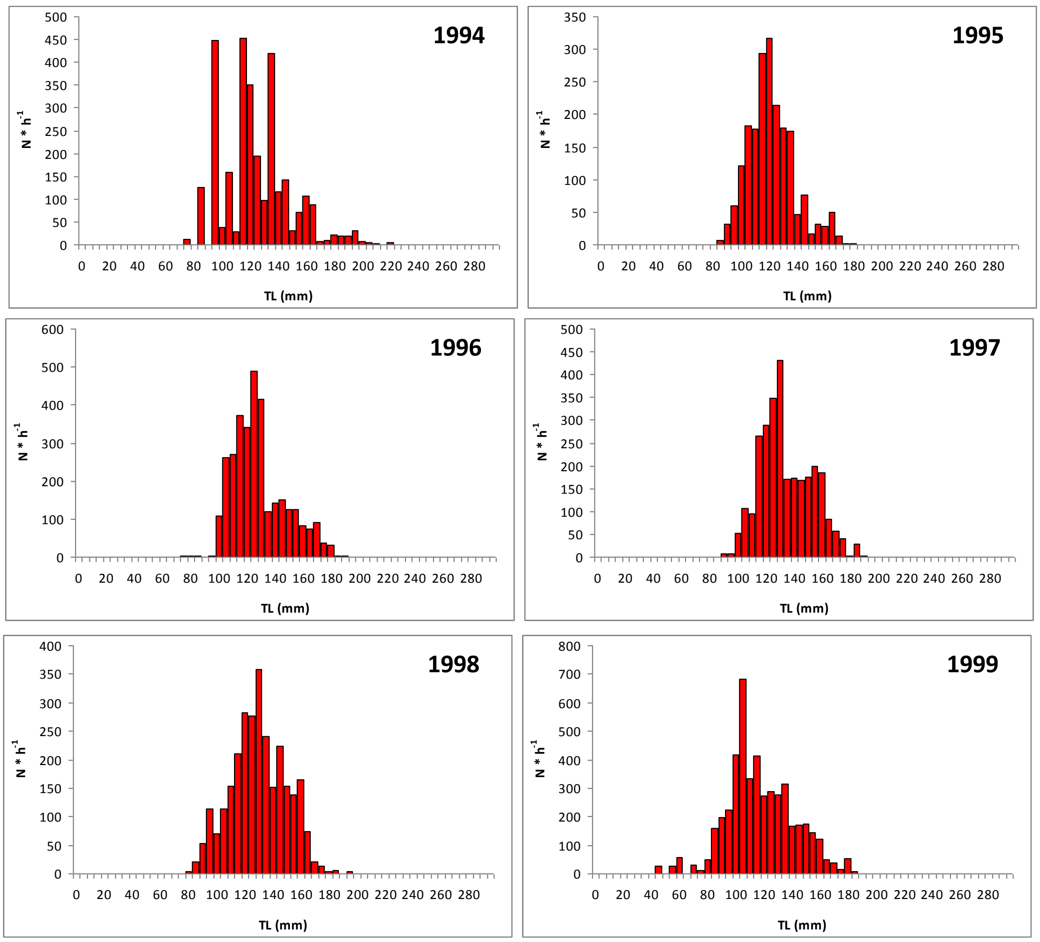


**Fig. 1.2.3.3 Stratified abundance indices by size of *Spicara flexuosa* in GSA 22&23, 1994-1999 based on MEDITS survey.**

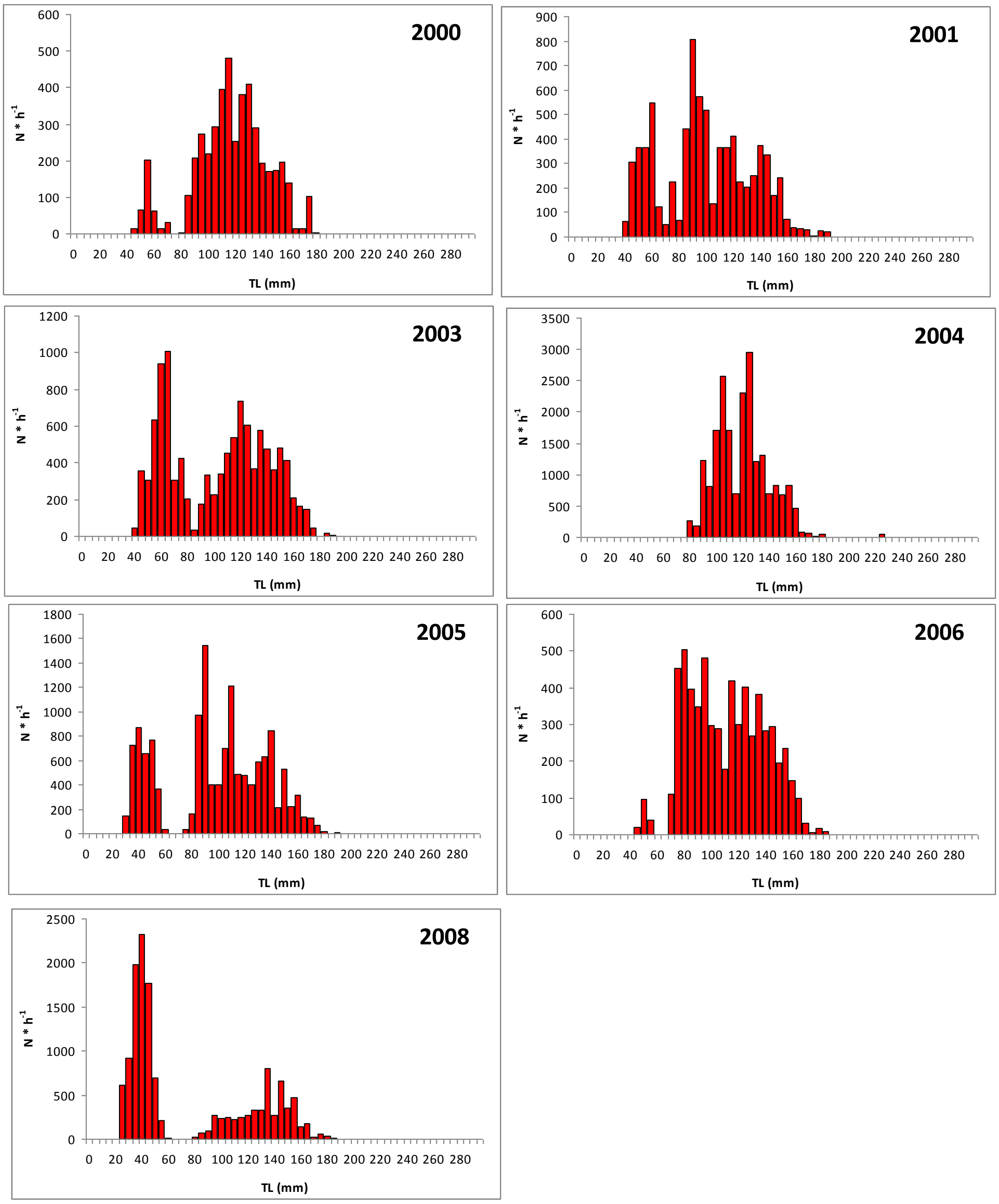


**Fig. 1.2.3.4. Stratified abundance indices by size of *Spicara flexuosa* in GSA 22&23, 2000-2008 based on MEDITS survey.**

### 1.2.4 *Assessment of historic stock parameters*

#### 1.2.4.1 Method 1: Stock Production Model

***Justification***

A production model has been employed in order to estimate the fishing mortality and the biomass at sea and the relative reference points in term of $F_{MSY}$ and $B_{MSY}$, using the catch and effort data estimated by Moutopoulos and Stergiou (2012).

***Input parameters***

A non-equilibrium dynamic biomass model incorporating covariates [ASPIC 5.10.1] (Prager 2005) was applied to catch and effort (HP x Days) data from the GSAs 22 & 23, of the main fishing fleet exploiting blotched picarel (small scale fishery). Three model shapes, namely: Logistic, Fox and the Generalized Estimate Exponent were used. In addition to data on catch and effort, ASPIC requires starting guesses and ranges for the parameters to be estimated by the model: carring capacity (K), maximum sustainable yield (MSY), the ratio of the biomass at the beginning of the first year to the carrying capacity (B1/K) and catchability (*q*) (Table 1.2.4.1).

Due to the low amount of landings observed for the other fisheries, the model has been run only using small scale vessels. Such decision provided better fit and more realistic values of $F_{MSY}$ and MSY, although they can be respectively slightly overestimated and underestimated.

**Table 1.2.4.1. ASPIC input parameters of the FIT mode for GSA 22 & 23.**

| B1/K | MSY | Range of MSY | K | Range of K | Fishing fleet | q (mean (CPUE) / 2*max(Y)) |
|---|---|---|---|---|---|---|
| 0.5 | 300 | 100 – 1000 | 3000 | 1000 - 4000 | Small scale | 4.1784E-09 |

After fitting the values for the above parameters, the FIT mode is run. At this point ASPIC computes estimates of parameters, including time trajectories of fishing intensity and stock biomass. The results of the fit were used to compute bias-corrected approximate confidence limits (80% CL) through bootstrap analysis. The model fittings are under the assumption that yield in each year is known more precisely than fishing effort or relative abundance. In other words, all model fittings were conditioned on yield, rather than on effort or relative CPUE (Prager 2005).

If there is normal convergence, the point estimates of the FIT mode were loaded in the BOT mode for bootstrapping. In this mode the programme computes bootstrap confidence intervals on estimated quantities. This approach re-samples the residuals from the optimum fit to generate new bootstrap samples of the observed time series. The residuals between the observed and predicted catch rates (CPUE), are used for bootstrap analysis. Bootstrap data sets are constructed by combining predicted CPUE with a randomly chosen residual to compute a pseudo-CPUE value. The model is then refit, using the pseudo-CPUE, which is assumed to relate back to stock biomass via the catchability coefficient (CPUE = qBt). The process is repeated at least 1000 times (bootstrap trials) for each different fit. At each trial the objective function used is the sum of squared errors (Haddon 2001, Prager 2005).

***Results***

Initial runs in the ASPIC FIT gave normal convergence only for the logistic and Fox models. The observed CPUE and predicted CPUE indexes are shown in Figure 1.2.4.1-2, for the logistic and Fox models respectively. A clear decreasing trend in CPUEs is observed for all the runs.

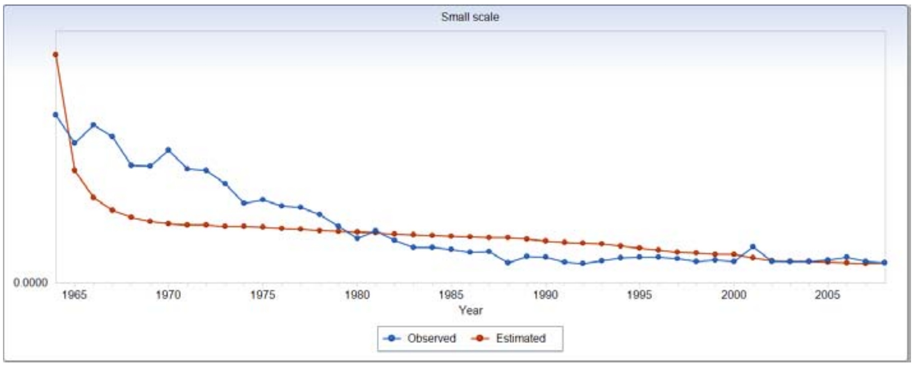


**Figure 1.2.4.1. Observed and predicted values of CPUE of blotched picarel in GSA 22&23 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1964-2008.**

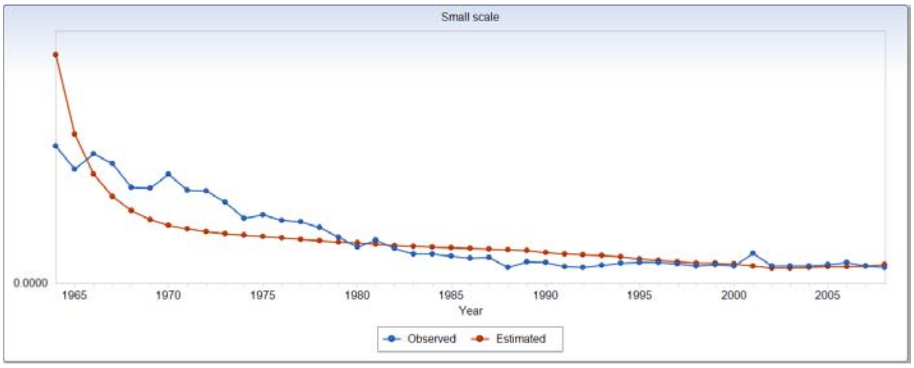


**Figure 1.2.4.2. Observed and predicted values of CPUE of blotched picarel in GSA 22&23 using the dynamic non-equilibrium Fox model in ASPIC for the period 1964-2008.**

In the logistic model the estimated biomass and fishing mortality fluctuated respectively from 14,000 to 1,000 t and from 0.10 to 2.1 (Figure 1.2.4.3). The biomass showed a clear decreasing trend from 1964 to 2008, while the F reached highest values in 2002. The estimated surplus production shows an increasing trend until 1995 followed by a stable period (Figure 1.2.4.4).

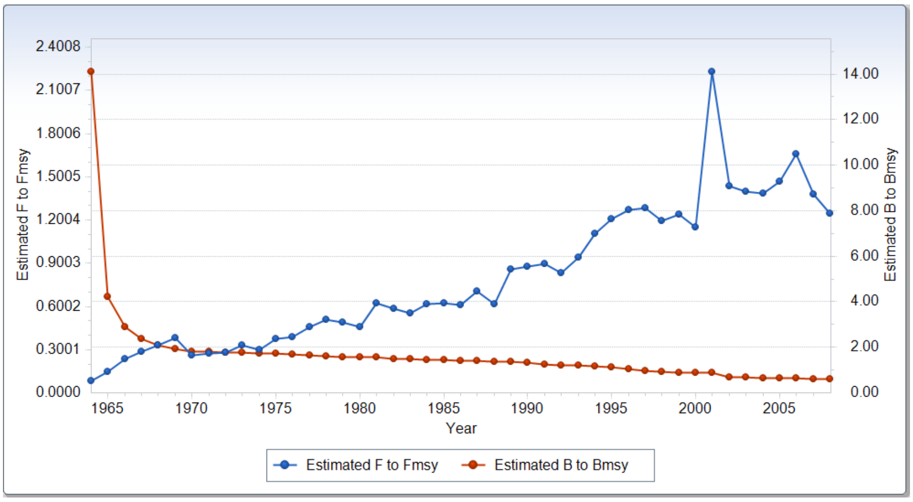


**Figure 1.2.4.3. Estimated average biomass and fishing mortality of blotched picarel in GSA 22&23 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1964-2008.**

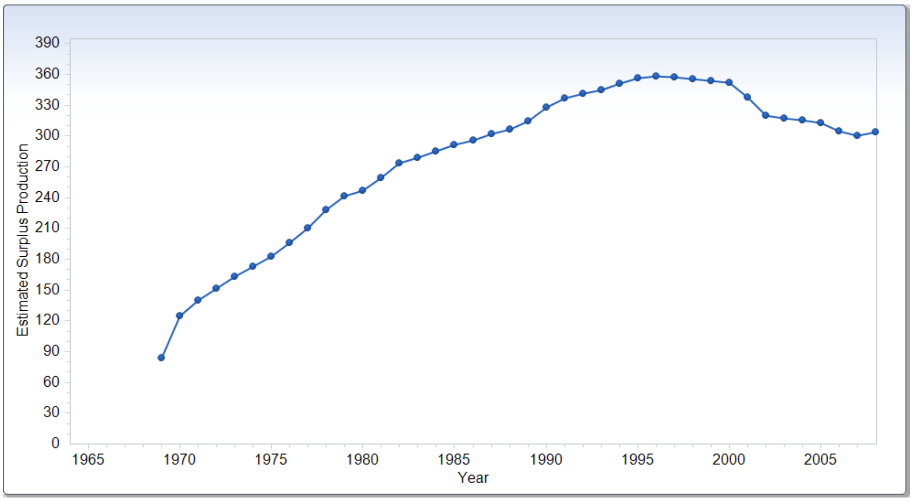


**Figure 1.2.4.4. Estimated surplus production of blotched picarel in GSA 22&23 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1964-2008.**

In the Fox model the estimated biomass and fishing mortality fluctuated respectively from 12,000 to 1,000 t and from 0.02 and 0.7 (Figure 1.2.4.5). The biomass showed a clear decreasing trend from 1964 to 2008, while the F reached highest values in 2002. The estimated surplus production shows an increasing trend until 1995 followed by a stable period (Figure 1.2.4.6).

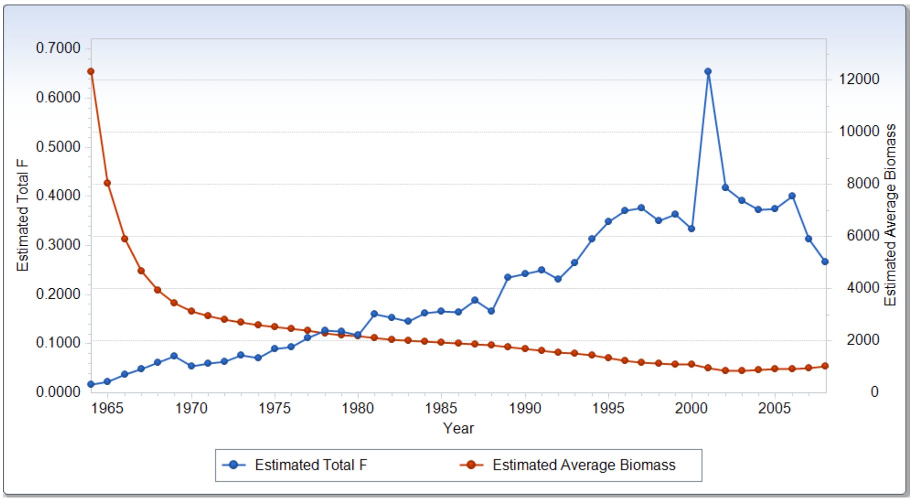


**Figure 1.2.4.5. Estimated average biomass and fishing mortality of blotched picarel in GSA 22&23 using the dynamic non-equilibrium Fox model in ASPIC for the period 1964-2008.**

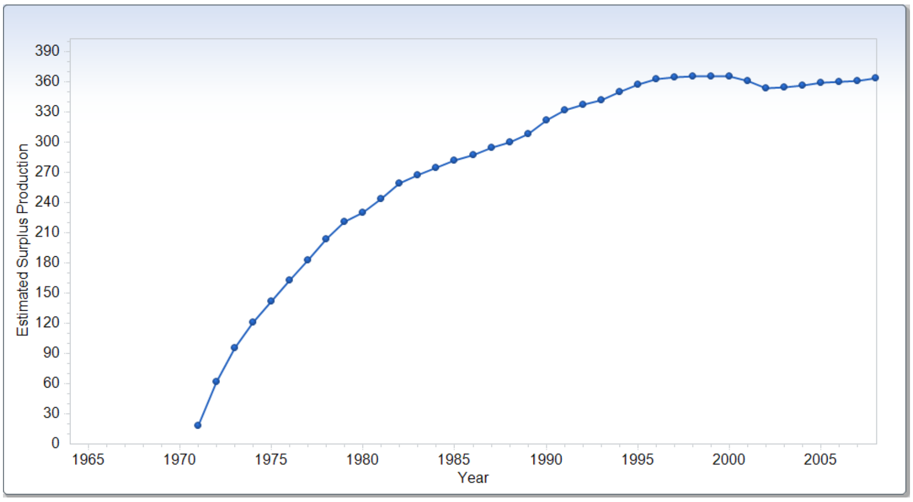


**Figure 1.2.4.6. Estimated surplus production of blotched picarel in GSA 22&23 using the dynamic non-equilibrium Fox model in ASPIC for the period 1964-2008.**

The goodness of fit of each model is presented in Table 1.2.4.2. The two models presented a general good fit, with the logistic model showing a better fit also in terms of contrast and nearness.

**Table 1.2.4.2. Goodness of fit results for the three model in ASPIC.**

| | |
|---|---|
| Logistic model | Loss component number and title / Weighted SSE / N / Weighted MSE / Current weight / Inv. var. weight / R-squared in CPUE<br>Loss(-1) SSE in yield 0.000E+00<br>Loss(0) Penalty for B1 > K 0.000E+00 1 N/A 0.000E+00 N/A<br>Loss(1) Small scale 8.098E+00 45 1.883E-01 1.000E+00 1.000E+00 0.536<br>TOTAL OBJECTIVE FUNCTION, MSE, RMSE: 8.09769179E+00 1.928E-01 4.391E-01<br>Estimated contrast index (ideal = 1.0): 3.7522 C* = (Bmax-Bmin)/K<br>Estimated nearness index (ideal = 1.0): 1.0000 N* = 1 - \|min(B-Bmsy)\|/K |
| Fox model | Loss component number and title / Weighted SSE / N / Weighted MSE / Current weight / Inv. var. weight / R-squared in CPUE<br>Loss(-1) SSE in yield 0.000E+00<br>Loss(0) Penalty for B1 > K 0.000E+00 1 N/A 0.000E+00 N/A<br>Loss(1) Small scale 5.157E+00 45 1.199E-01 1.000E+00 1.000E+00 0.617<br>TOTAL OBJECTIVE FUNCTION, MSE, RMSE: 5.15671979E+00 1.228E-01 3.504E-01<br>Estimated contrast index (ideal = 1.0): 5.0100 C* = (Bmax-Bmin)/K<br>Estimated nearness index (ideal = 1.0): 1.0000 N* = 1 - \|min(B-Bmsy)\|/K |

**Table 1.2.4.3. Estimated parameters of picarel in GSA 22 & 23.**

| Model | MSY (tons) | $B_{MSY}$ (tons) | $F_{MSY}$ | $f_{MSY}$ Small scale |
|---|---|---|---|---|
| Logistic | 358 | 1535 | 0.239 | 5.245E+07 |
| Fox | 365 | 1104 | 0.331 | 7.013E+07 |

The estimates of MSY and $F_{MSY}$ ranges after bootstrapping using approximate 80% upper and lower confidence limits are shown in Table 1.2.4.3-4.

**Table 1.2.4.4. Estimates of MSY and $F_{MSY}$ from bootstrapped analysis in ASPIC with confidence limits.**

| Model | MSY 80% lower | MSY | MSY 80% higher | $F_{MSY}$ 80% lower | $F_{MSY}$ | $F_{MSY}$ 80% higher |
|---|---|---|---|---|---|---|
| Logistic | 353 | 358 | 364 | 0.235 | 0.239 | 0.243 |
| Fox | 358 | 365 | 375 | 0.325 | 0.331 | 0.340 |

The relative biomass ($B/B_{MSY}$) and fishing mortality ($F/F_{MSY}$) are showed in figure 1.2.4.7 for the two models.

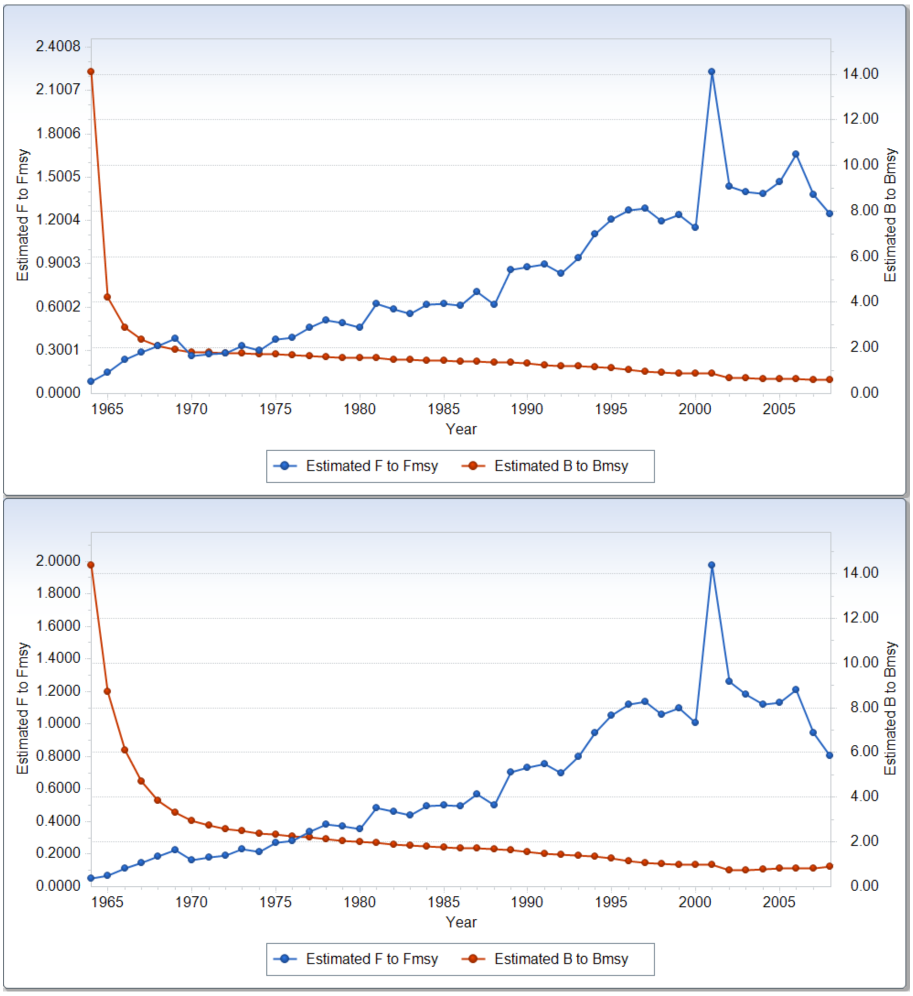


**Figure 1.2.4.7. Historic trend in estimated fishing mortality as $F/F_{MSY}$ ratio and biomass as B/BMSY ratio from Logistic (upper grapf), Fox (lower graphs) models.**

The results of the production models suggest that blotched picarel in the GSA 22&23 is overexploited, considering that the current F estimated in the logistic model, which presents a better goodness of fit, is around 1.25 times the $F_{MSY}$. The biomass at sea is below the $B_{msy}$, with the current B around 60% of the $B_{MSY}$ ($B/B_{MSY}$ = 0.60 from the fox model).

### 1.2.4.2 Method 2: SURBA

***Justification***

The relatively long time series of data available from the MEDITS surveys provided the most useful data sets for analysis. The survey-based stock assessment approach SURBA (Needle, 2003) was used on MEDITS (1994-2009) data of *Spicara flexuosa* caught in GSAs 22&23. Length was converted to ages based on the growth equation presented in section 1.1.1.2 for both sexes (Soykan et al., 2010). Age groups 0 to 7 were identified. However, age group 0 was considered largely under-sampled and ages 4 to 7 were merged as a plus group. Thus ages 1 to 4+ were used for analysis. Mean weight at age was a weighted mean based on the length frequency distribution of each age class. Average values were used for the years with missing info. Natural mortality were estimated as a vector for each age group based on ProdBiom (Abella et al., 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. $F_{ref}$ was set for ages 1 to 3. Young ages of *Spicara flexuosa* exhibit a very coastal distribution that MEDITS survey is unsuitable to capture. Thus a catchability pattern was defined, assuming catchability q equal to 0.25 (highly under-sampled) and 0.7 for ages 1 and 2 and 1 for ages 3 and 4+.

***Input parameters***

**Table. 1.2.4.8. *Spicara flexuosa* in GSAs 22&23. Input parameters, number at age.**

| **Survey indexes (n/h)** | Age 1 | Age 2 | Age 3 | Age 4+ |
|---|---|---|---|---|
| 1994 | 0.294026 | 0.277068 | 0.09366 | 0.083486 |
| 1995 | 0.199908 | 0.204299 | 0.039288 | 0.004395 |
| 1996 | 0.179696 | 0.241599 | 0.096392 | 0.028303 |
| 1997 | 0.087627 | 0.203807 | 0.117164 | 0.021504 |
| 1998 | 0.120464 | 0.194892 | 0.112231 | 0.008071 |
| 1999 | 0.376932 | 0.190959 | 0.108526 | 0.019117 |
| 2000 | 0.332918 | 0.23724 | 0.130713 | 0.021168 |
| 2001 | 0.502544 | 0.198219 | 0.203488 | 0.021079 |
| 2002 | -99 | -99 | -99 | -99 |
| 2003 | 0.360294 | 0.40056 | 0.302346 | 0.038527 |
| 2004 | 1.474057 | 1.311658 | 0.508592 | 0.035393 |
| 2005 | 0.810371 | 0.359233 | 0.308403 | 0.036467 |
| 2006 | 0.344173 | 0.23173 | 0.172343 | 0.011132 |
| 2007 | -99 | -99 | -99 | -99 |
| 2008 | 0.222732 | 0.296296 | 0.300034 | 0.022775 |

Not available data due to the lack of survey are indicated as -99.

**Table 1.2.4.9. Weight at age in the stock (in kg) of *Spicara flexuosa* stock in GSA 22&23 for 1999-2008.**

| | Age 1 | Age 2 | Age 3 | Age 4+ |
|---|---|---|---|---|
| 1994 | 0.01086 | 0.01729 | 0.02354 | 0.04740 |
| 1995 | 0.01296 | 0.02213 | 0.02644 | 0.04662 |
| 1996 | 0.01056 | 0.01762 | 0.02439 | 0.04641 |
| 1997 | 0.01079 | 0.01786 | 0.02335 | 0.04746 |

| | | | | |
|---|---|---|---|---|
| 1998 | 0.01099 | 0.01764 | 0.02305 | 0.04619 |
| 1999 | 0.01086 | 0.01759 | 0.02328 | 0.04648 |
| 2000 | 0.01084 | 0.01776 | 0.02219 | 0.04619 |
| 2001 | 0.01731 | 0.02367 | 0.03313 | 0.04898 |
| 2002 | 0.01137 | 0.01821 | 0.02410 | 0.04662 |
| 2003 | 0.01085 | 0.01761 | 0.02408 | 0.04701 |
| 2004 | 0.01094 | 0.01789 | 0.02256 | 0.04656 |
| 2005 | 0.00803 | 0.01399 | 0.01973 | 0.04299 |
| 2006 | 0.01099 | 0.01755 | 0.02352 | 0.04689 |
| 2007 | 0.01137 | 0.01821 | 0.02410 | 0.04662 |
| 2008 | 0.01189 | 0.01811 | 0.02399 | 0.04689 |

**Growth parameters (Soykan et al., 2010)**

| $L_\infty$ | k | $t_0$ |
|---|---|---|
| 21.99 cm | 0.255 $y^{-1}$ | -1.16 y |

| Length-weight relationships (Karakulak et al., 2006) | |
|---|---|
| a | b |
| 0.0028 | 3.505 |

| Maturity at Age (Based on GSA 25 estimates) | | | |
|---|---|---|---|
| Age 1 | Age 2 | Age 3 | Mean Age 4+ |
| 0.3 | 0.95 | 1 | 1 |

| Natural mortality (M) | | | |
|---|---|---|---|
| Age 1 | Age 2 | Age 3 | Mean Age 4+ |
| 0.83 | 0.69 | 0.63 | 0.58 |

### *Results including sensitivity analyses*

The residual plots of log catchabilities show no apparent trend or pattern.

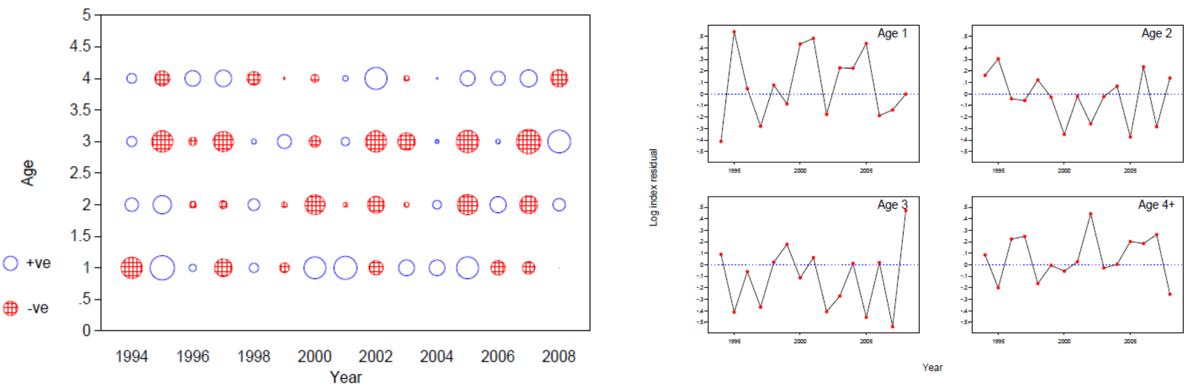


**Fig. 1.2.4.10. SURBA model. Residual plot of log index catchabilities per age and year of *Spicara flexuosa* in GSA 22&23 (1994-2008).**

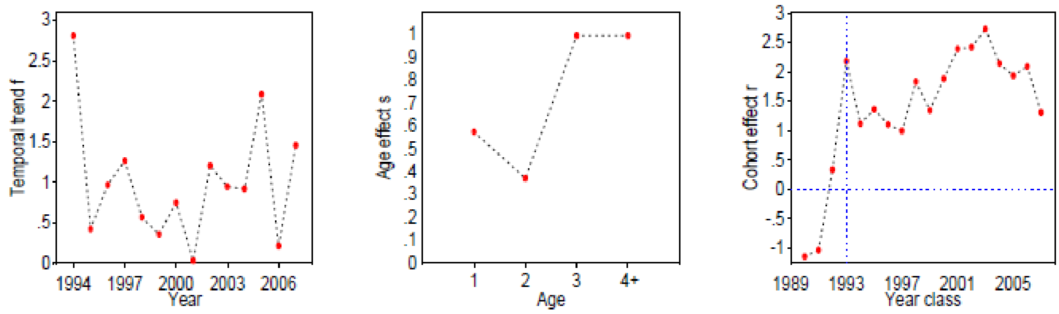


**Fig. 1.2.4.11. MEDITS survey. Fitted year, age and cohort effects estimated by SURBA.**

Fitted year effect, that is the model proxy for the combination of fishing effort and mean natural mortality in the underlying population, is highly variable not presenting a specific trend. Fitted age effect shows an increase from age 2 to age 4+, while fitted cohort effect shows an increasing trend up to 2002 falling afterwards (Figure 1.2.4.11).

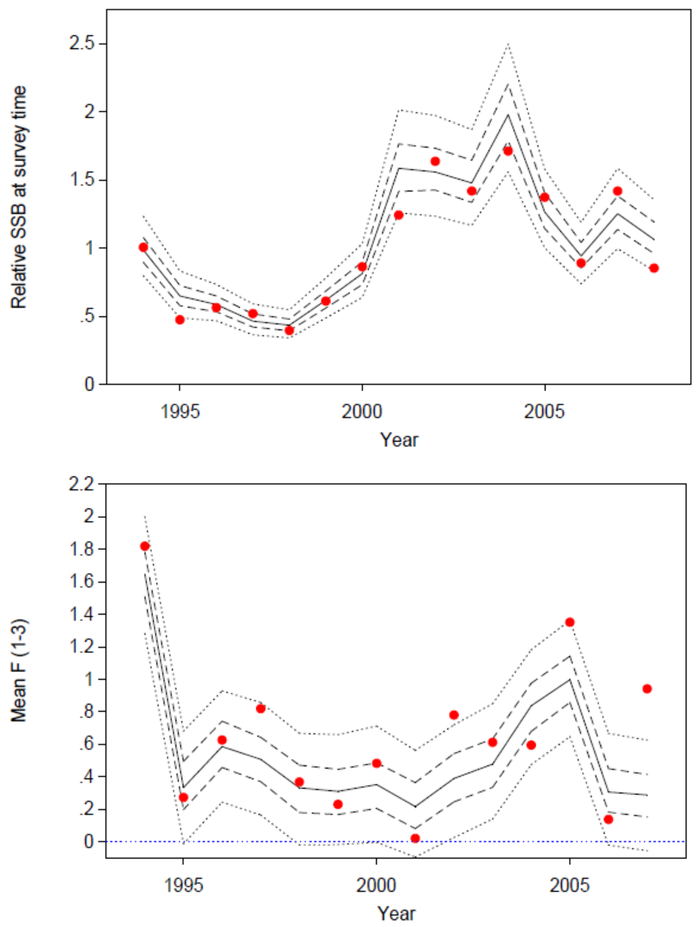


**Fig. 1.2.4.11. MEDITS survey. Estimated trend in F and relative SSB using SURBA. 50$^{th}$ percentile of bootstrapped runs (solid line) and 5% and 95% percentiles of bootsrapped runs (dashed lines).**

The model estimates no apparent trend in the mean F being around 0.6, after 1995. An increase in relative SSB is observed after 2001 and a fall is estimated after 2005 (Figure 1.2.4.11).

Model diagnostics are shown in the following Fig. 1.2.4.12 indicating a reliable model fit. Retrospective analysis was applied in the SURBA model for the period 1994-2008 with 8 years backward analysis. Results are presented in Fig. 1.2.4.13 showing no particular retrospective bias. The assessment is generally considered reliable.

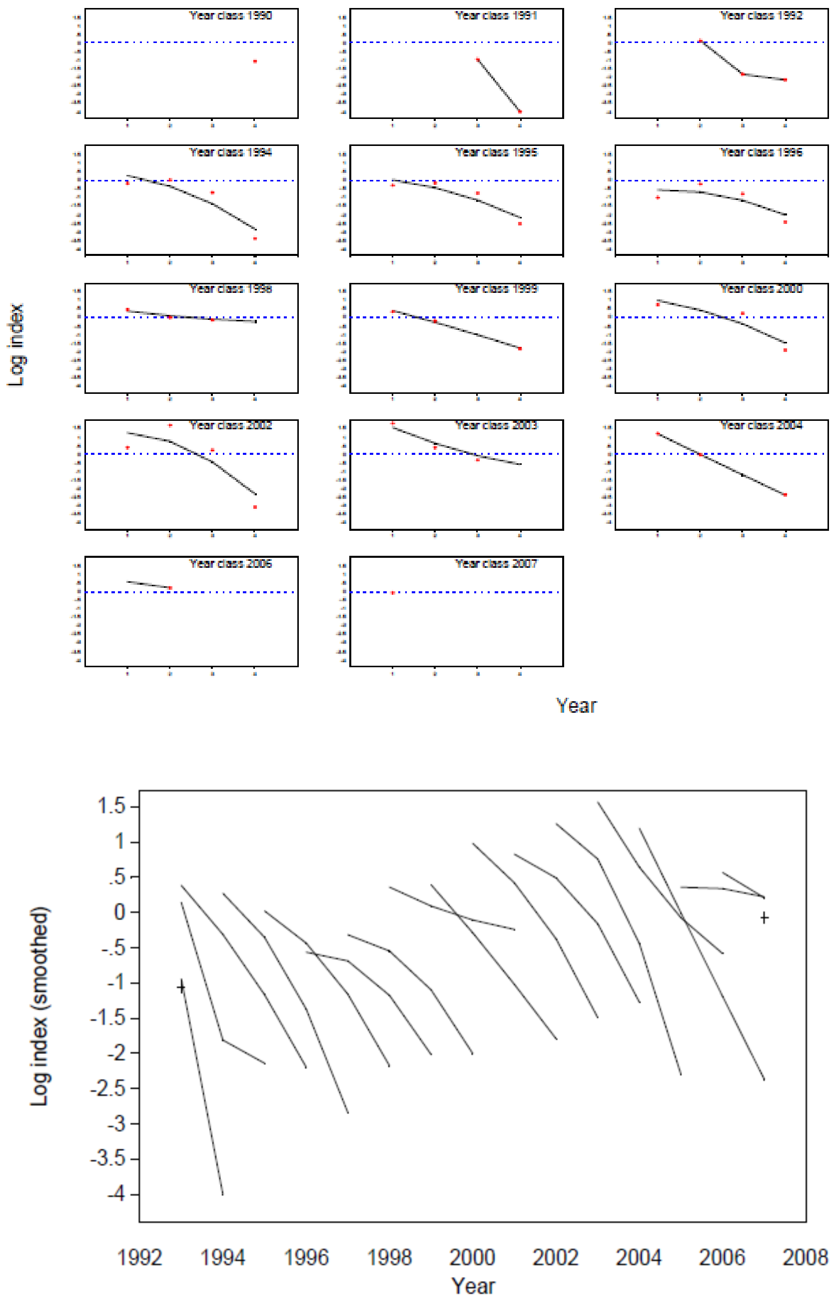


**Fig. 1.2.4.12. Model diagnostics for *Spicara flexuosa* SURBA model in the GSA 22&23 (MEDITS data). Top: Comparison between observed (points) and fitted (lines) survey abundance indices, for each year. Bottom: Log survey abundance indices by cohort. Each line represents the log index abundance of a particular cohort throughout its life.**

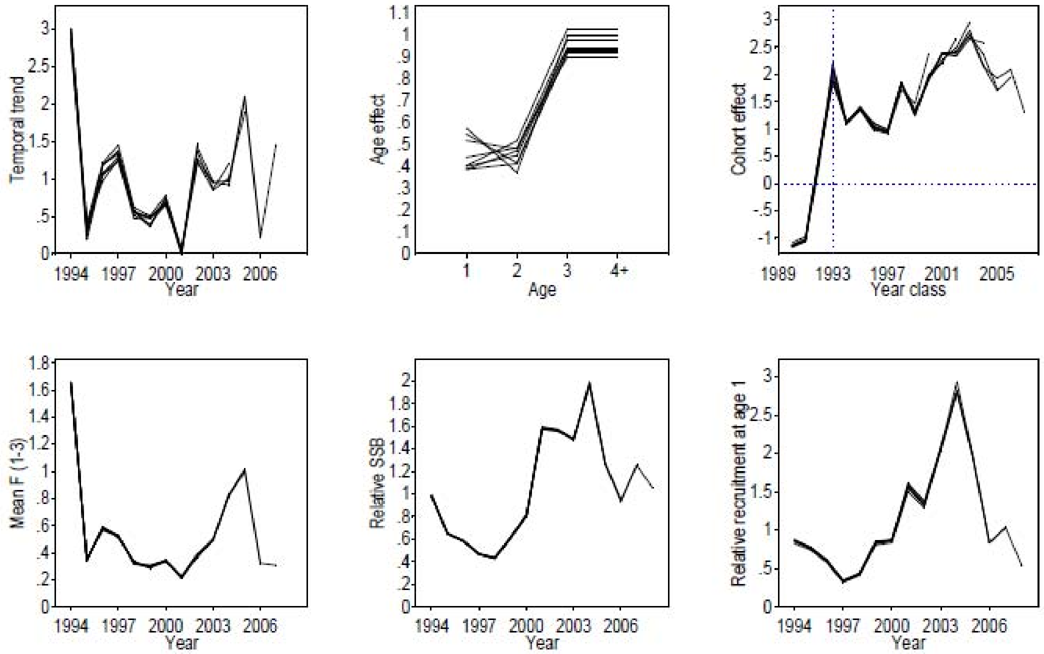


**Fig. 1.2.4.13. Model diagnostics for *Spicara flexuosa* SURBA model in the GSA 22&23 (MEDITS data). Results of retrospective analysis with 8 years period.**

## 1.2.5 *Long term prediction*

### 1.2.5.1 Justification

Long-term prediction was not conducted.

## 1.2.6 *Data quality*

Survey data are derived from MEDITS surveys, which end in 2008. Data for the ASPIC Surplus Production Models were derived from a reconstructed series back to 1964. However, no discard time series are available, so discards, which for this species can be very high, were not taken into account. The same is also true of illegal and unreported landings as well as subsistence landings. Since the vast majority of blotched picarel landings are caught with artisanal vessels, generally operating close to the coast, and assuming, based on its small body size, and the fact that blotched picarel is constituted by local populations, it is likely that landings and thus assessments are not critically affected by the landings of Turkish fleets.

## 1.2.7 *Scientific advice*

### 1.2.7.1 Short term considerations

***State of the spawning stock size***

The results of the short time series of data do not allow concluding on reference points of $B_{lim}$ or $B_{pa}$. In the absence of proposed or agreed references, the EWG is unable to fully evaluate the state of the stock and provide scientific advice.

ASPIC results showed the biomass at sea is below the $B_{msy}$, with the current biomass being around 60% of the $B_{MSY}$ ($B/B_{MSY}$ = 0.60 from the fox model).
Based on SURBA results an increase in the SSB is foreseen since 2001, however the lack of data after 2008 prevents the verification of the model output. No absolute estimates are possible since SURBA output is a relative index of SSB.

***State of recruitment***

SURBA model results showed an increase in recruitment up to 2003 and a decrease since then up to 2008. No absolute estimates are possible since SURBA output is a relative index of recruitment.

***State of exploitation***

Based on SURBA results, the mean fishing mortality (averaged over ages 1 to 3) is highly variable but showed a clear decreasing trend since 2005. It is important to notice that SURBA provide useful information on the trend of F and not on its absolute value, as long as it is not possible to verify if selection at age of the MEDITS is comparable with these of the commercial gears.

The results of the production models suggest that blotched picarel in GSA 22&23 is exploited unsustainably, since current F estimated by ASPIC is around 1.2 times the $F_{MSY}$ ($F/F_{MSY}$ = 1.2 from the Fox model).

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## 1.3 **Stock assessment of bogue in GSA 20**

### 1.3.1 *Stock identification and biological features*

#### 1.3.1.1 Stock Identification

*Boops boops* (bogue) is a common Mediterranean fish species found on the shelf or coastal pelagic on various bottoms from 50 m down to 200 m depth (Kallianiotis 1992). It forms schools ascending close to the surface during the night. It is a sequential protogynous hermaphrodite fish, which displays sexual dimorphism during the reproductive period (Bauchot, and Hureau, 1986, Kallianiotis 1992). Kallianiotis (1992) showed that the dispersal of the species on the Cretan Continental shelf is characterised by seasonal fluctuations in the bathymetric distribution and the relative abundance of different length and age groups. Young fish are abundant in shallow coastal waters, older and bigger fish are being progressively more abundant as the depth increases up to 200 m where most fish are 3-4 years old. Migration between the juvenile grounds to deeper water feeding grounds and then back to shallow waters to spawn is characteristic of the life cycle of bogue. Bigger and older fish migrate towards deeper water during early summer.

#### 1.3.1.2 Growth

The von Bertalanffy growth parameters of bogue used were the ones estimated by Kallianiotis (1992) estimating Linf=294 cm, k=0.2, to=-1.49 were utilized in the analyses of GSA 20.

Parameters of the length-weight relationship, related to combined sex, are: a=0.000005, b = 3.137 (for length expressed in mm) based on estimates of HCMR landings information.

#### 1.3.1.3 Maturity

The maturity ogive of the stock (sex combined), is presented in Table 1.3.1.1. Data used were collected under the Italian National Programme during 2006-2008 in GSA 18. Boops boops is known to spawn during winter and the fecundity of older age classes is known to decrease (Kallianiotis 1992).

**Tab. 1.3.1. 1. Maturity ogive of *Boops boops.***

| Age | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| Prop. Mature | 0 | 0.1116 | 0.93 | 1 | 1 | 1 | 1 | 1 | 1 |

### 1.3.2 *Fisheries*

#### 1.3.2.1 General description of fisheries

During the years 1970 - 2008 the mean annual Mediterranean production of bogue was 26,000 tonnes. Less than 3% of the total annual Mediterranean production of bogue is caught in Ionian Sea (FAO-FishStat, 2011, Fig. 1.3.1.1) being on average around 900 tonnes during the 2000s.

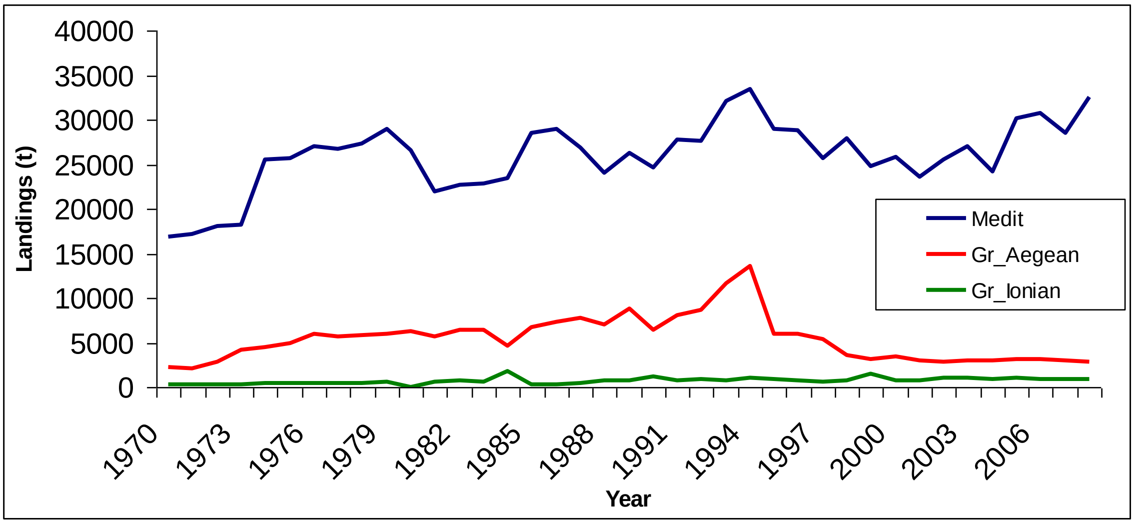


**Fig. 1.3.2.1. Landings information on bogue in the Mediterranean Sea and the western part of Ionian Sea (Greek part of GSA 20).**

## 1.3.2.2 Management regulations applicable in 2010 and 2011

## 1.3.2.3 Catches

***Landings***

The landings of *Boops boops* in GSA 20 by the main fisheries for the period 1964-2008 are given in Figure 1.3.1.2. This info is based on EVOMED data provided to the WG, data from Moutopoulos and Stergiou (2012) and data to FAO GFCM and DCF. The species in the Ionian Sea is mainly caught mainly by the purse seiners and the artisanal boats. Small quantity is landed by trawlers and the beach seines (see also Section 1 in the current report).

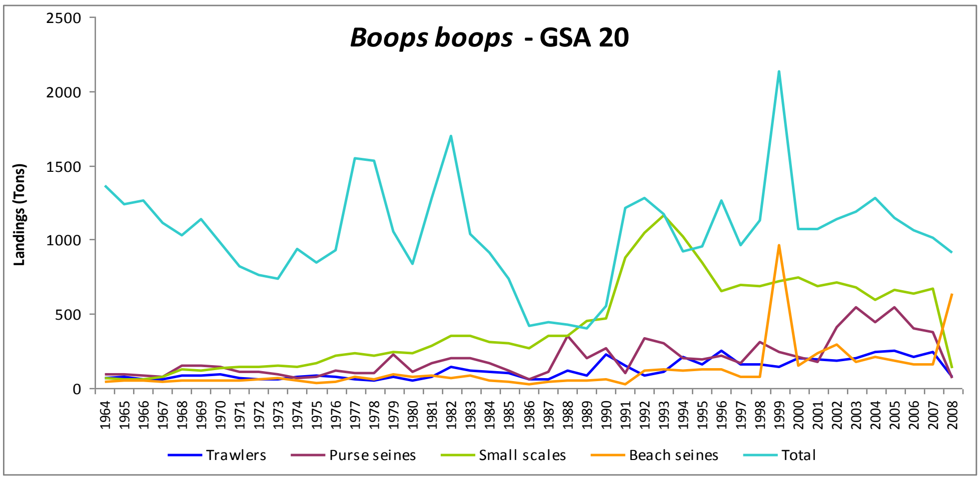


**Fig. 1.3.2.2. Landings of *B. boops* in GSA 20 (only Greek part) by fishing gear for the period 1964-2008.**

***Discards***

In Ionian Sea, bogue discards ratio for purse seines is less than 1% of the annual bogue landings for the specific gear (Tsagarakis et al. 2012). Beach seines however are reported to discard on average 12% of their bogue catch (Petrakis et al. 2009). Concerning the artisanal fishery, Tzanatos et al. (2007) report up to 37% of bogue in Patraikos gulf (GSA 20). No estimates are available for trawlers, however the $L_{50}$ for discards is around 11.7 cm (Machias et al., 2007).

***Fishing effort***

Fishing effort data in GSA 20 were provided according to the 2009 Official EC Data Call. Table 1.3.2.1 lists the reported effort for bottom trawler (OTB), small scale fishery (GTR and LLS), purse seine (PS) and beach seine (SB) in GSA 20.

**Tab. 1.3.2.1. Effort in GSA 20 expressed in (KW*DAYS)/1000, 2003-2008.**

| YEARS | GTR | LLS | OTB | PS | SB |
|---|---|---|---|---|---|
| **2003** | 68846 | 1888 | 15793 | 9389 | 2776 |
| **2004** | 70634 | 4977 | 15875 | 9141 | 2207 |
| **2005** | 70747 | 2716 | 17731 | 9656 | 2194 |
| **2006** | 66781 | 3848 | 16424 | 8993 | 2022 |
| **2008** | 50244 | 7915 | 16013 | 8234 | 1775 |

### 1.3.3 *Scientific surveys*

MEDITS

***Methods***

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 20 the following numbers of hauls were reported per depth stratum (Tab. 1.3.3.1).

**Tab. 1.3.3.1. Number of hauls per year and depth stratum in GSA 20.**

| Stratum | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2003 | 2004 | 2005 | 2006 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **010-050** | 1 | 2 | 2 | 2 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **050-100** | 3 | 4 | 8 | 7 | 11 | 10 | 11 | 9 | 10 | 10 | 10 | 9 | 10 |
| **100-200** | 1 | 3 | 4 | 2 | 5 | 6 | 5 | 6 | 6 | 6 | 5 | 6 | 6 |
| **200-500** | 2 | 3 | 4 | 4 | 7 | 7 | 7 | 8 | 8 | 9 | 8 | 8 | 7 |
| **500-800** | 1 | 2 | 4 | 3 | 5 | 5 | 5 | 5 | 5 | 3 | 5 | 4 | 6 |
| **TOTAL** | 8 | 14 | 22 | 18 | 32 | 31 | 31 | 31 | 32 | 31 | 31 | 30 | 32 |

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma \, (Yi*Ai) / A$$

$$V(Yst) = \Sigma \, (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

***Geographical distribution patterns***

Figure 1.3.3.3 provides the distribution of sampling hauls of the MEDITS survey in GSA 20.

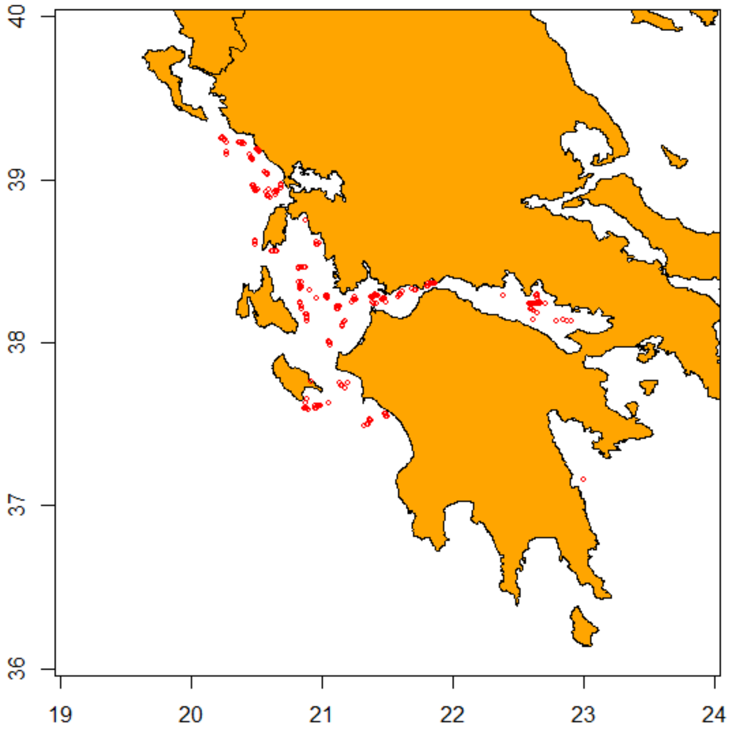


**Fig. 1.3.3.3. Distribution of sampling hauls of the MEDITS survey in GSA 20.**

***Trends in abundance and biomass***

Fishery independent information regarding the state of the bogue in GSA 20 was derived from the international survey MEDITS.

Figure 1.3.3.4 displays the estimated trend in bogue abundance and biomass in GSA 20. The estimated abundance index reveals very low levels in number until 2001 and a sharp increase afterwards.

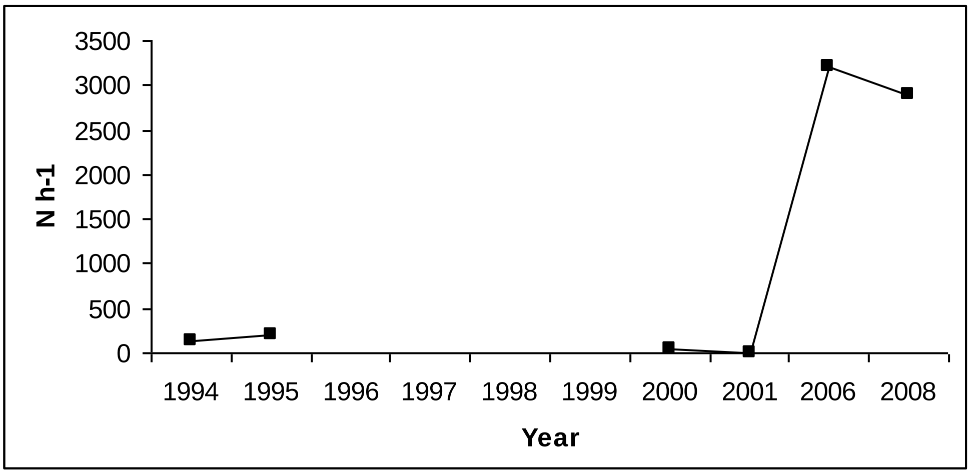


**Fig. 1.3.3.4. Abundance and biomass indices of bogue in GSA 20.**

*Trends in abundance by length or age*

The following Figs. 1.3.3.5-6 displays the stratified abundance indices of GSA 20 in 1994-2008.

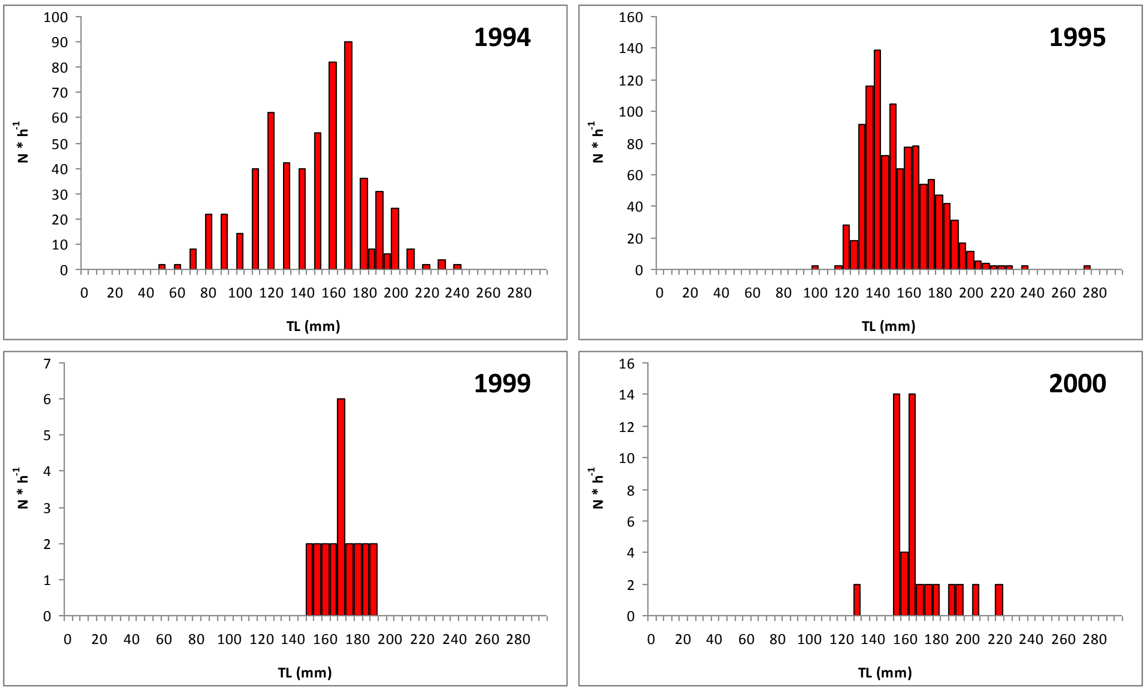


**Fig. 1.3.3.5. Stratified abundance indices by size of bogue in GSA 20, 1994-2000.**

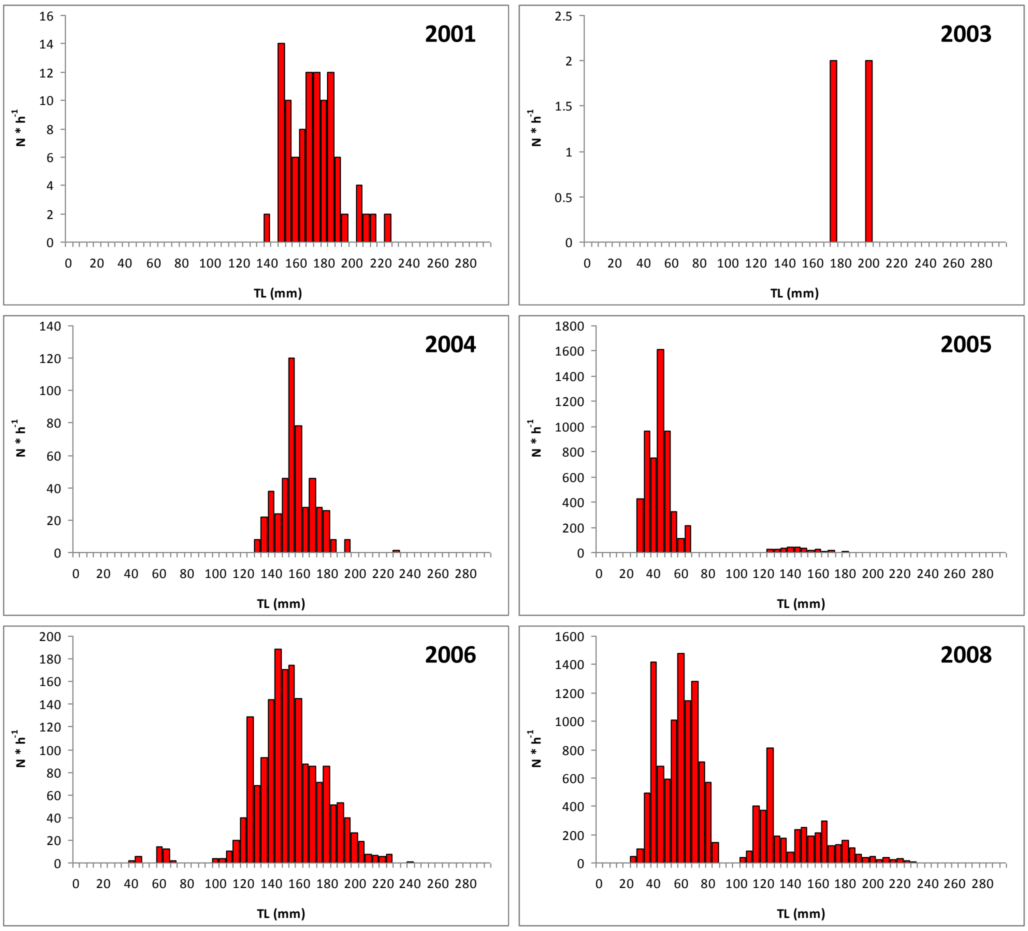


**Fig. 1.3.3.6. Stratified abundance indices by size of bogue in GSA 20, 2001-2008.**

## 1.3.4 *Assessment of historic stock parameters*

### 1.3.4.1 Method 1: Stock Production Model

***Justification***

A production model has been employed in order to estimate the fishing mortality and the biomass at sea and the relative reference points in term of $F_{MSY}$ and $B_{MSY}$, using the catch and effort data estimated by Moutopoulos and Stergiou 2012.

***Input parameters***

The analysis was performed using the ASPIC.5.3 software (A Stock-Production model Incorporating Covariates) (Prager, 1994, 2005) assuming a Schaefer (1954) model. This program implements a nonequilibrium, continuous-time, observation-error estimator for the dynamic production model (Schnute, 1977; Prager, 1994). The model was used to estimate K, MSY, the ratios of both current biomass or F to the biomass or F at which MSY can be attained, and q (the catchability coefficient, the proportion of total stock removed by one unit of fishing effort).

Input data consists of 3 pairs of time series of total landings (in t) and standardized fishing effort expressed as fishing days * total HP for GSA 20 for the different fishing gears: trawls-OTB, purse-seines-PS, and small scale gears-GNS+LLS) using the catch and effort data (Fig. 2.1.2.2.1.1) estimated by Moutopoulos and Stergiou (2012). Beach seines were not included in the analysis because their landings were very low compared to other gears and there was a dubious peak in the time series. The possibility of using at the same time several data sets is a new extension incorporated in the ASPIC new versions.

In addition to data on catch and effort, ASPIC requires starting guesses and ranges for the parameters to be estimated by the model: carrying capacity (K), maximum sustainable yield (MSY), the ratio of the biomass at the beginning of the first year to the carrying capacity (B1/K) and catchability (q) (Table 1.3.4.1).

**Table 1.3.4.1. ASPIC input parameters of the FIT mode for bogue in GSA 20.**

| **B1/K** | **MSY** | **Range of MSY** | **K** | **Range of K** | **Fishing fleet** | **q (mean (CPUE) / 2*max(Y))** |
|---|---|---|---|---|---|---|
| 0.80 | 12400 | 100 - 10000 | 14000 | 3000 - 100000 | Trawlers | 2.1960E-07 |
| | | | | | Purse seine | 3.3990E-08 |
| | | | | | Small scale | 2.2720E-07 |

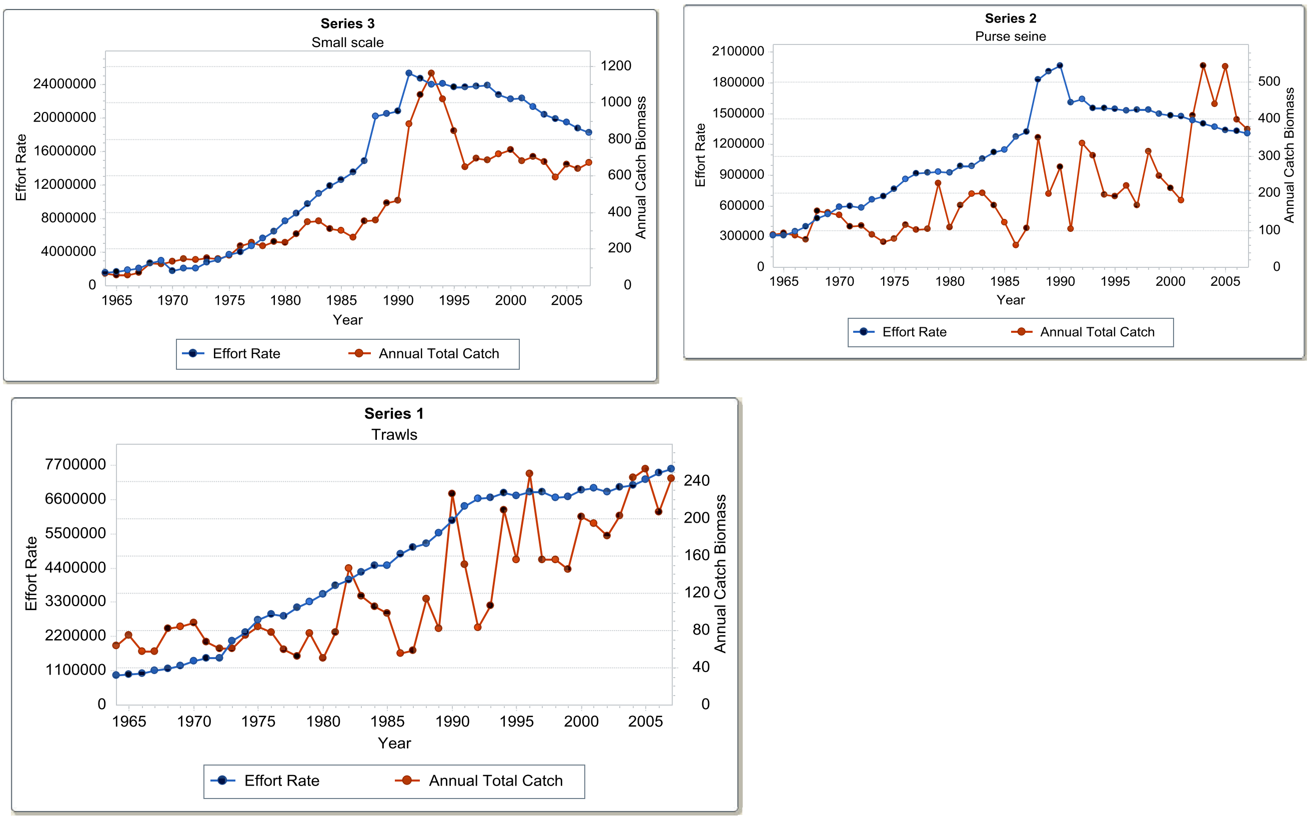


**Fig. 1.3.4.1. Input data for ASPIC for the different fishing gears (i.e. trawls (OTB), purse-seines (PS), and small scale gears (GNS and LLS) for bogue in GSA 20.**

After fitting the values for the above parameters, the FIT mode is run. This way ASPIC computes estimates of parameters, including time trajectories of fishing intensity and stock biomass. No bootstrap analysis was carried out to compute bias-corrected approximate confidence limits (80% CL).

***Results***

As follows the main results of the analysis for bogue in GSA 20 are shown below. The goodness of fit of each model is presented in Table 1.3.4.2. The results are presented in Figure 1.3.4.8. The observed CPUE and predicted CPUE indexes are shown in Figures 1.3.4.9. No clear trend in CPUEs is observed.

**Table 1.3.4.2. ASPIC analysis for bogue in GSA 20.**

| | Weighted SSE | N | Weighted MSE | Current Weight | Inv Var weight | R-squared in CPUE |
|---|---|---|---|---|---|---|
| Loss component number and title | | | | | | |
| Loss(-1) SSE in yield | 0.00E+00 | | | | | |
| Loss(0) Penalty for B1 > K | 4.796E-01 | 1 | N/A | 1.00E+00 | N/A | |
| Loss(1) Trawls | 6.748E+00 | 44 | 1.607E-01 | 1 | 9.158E-01 | 0.367 |
| Loss(2) Purse seine | 9.519E+00 | 44 | 2.266E-01 | 1 | 6.492E-01 | 0.001 |
| Loss(3) Small scale | 4.306E+00 | 44 | 1.025E-01 | 1 | 1.435E+00 | -0.064 |
| | | | | | | |
| TOTAL OBJECTIVE FUNCTION, MSE, RMSE: | 2.10531079E+01 | | 1.671 E-01 | 4.088E-01 | | |
| Estimated contrast index (ideal = 1.0): | 1.1346 | | C* = (Bmax-Bmin)/K | | | |
| | | | | | | |
| Estimated nearness index (ideal = 1.0): | 0.63591 | | N* = 1 - \|μιν(B-Bμσυ)\|/K | | | |

The estimate of q for the trawl fleet was at program-set bound that makes the model output trivial and results should be examined carefully. This makes the EWG suggest that the model output is not reliable for the assessment of bogue in GSA 20.

**Table 1.3.4.3. Estimated parameters of bogue in GSA 20.**

| | **MSY (tons)** | **$B_{MSY}$ (tons)** | **$F_{MSY}$** | **$f_{MSY}$ Trawls** | **$f_{MSY}$ Purse seine** | **$f_{MSY}$ Small scale** |
|---|---|---|---|---|---|---|
| **Logistic** | 2237 | 7124 | 0.349 | 1.430E+08 | 2.458E+07 | 1.166E+08 |

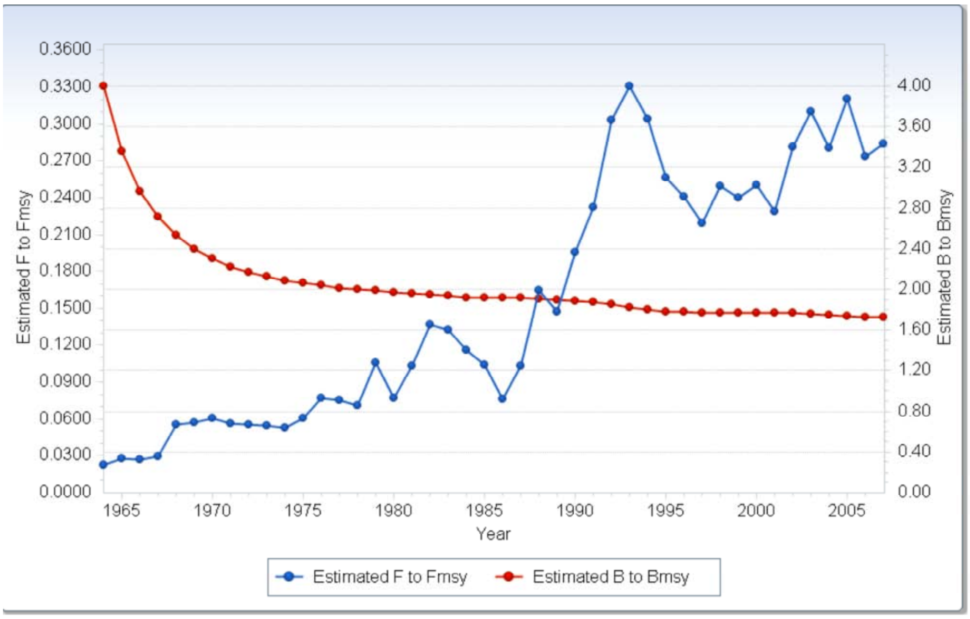


**Fig. 1.3.4.2. Historic trend in estimated fishing mortality as $F/F_{MSY}$ ratio and biomass as $B/B_{MSY}$ ratio.**

**Table 1.3.4.4. Estimated Population Trajectory.**

| Year | Estimated Total F mort | Estimated Starting biomass | Estimated Average biomass | Observed Total yield | Model Total yield | Estimated Surplus production | Ratio F mort to Fmsy | Ratio biomass to Bmsy |
|---|---|---|---|---|---|---|---|---|
| 1964 | 0.02 | 12600 | 1.09E+04 | 215.7 | 215.7 | -2458 | 0.0357 | 2.764 |
| 1965 | 0.024 | 9881 | 9473 | 225.5 | 225.5 | -455.2 | 0.0428 | 2.175 |
| 1966 | 0.022 | 9201 | 9083 | 199.6 | 199.6 | 0.9418 | 0.0395 | 2.026 |
| 1967 | 0.023 | 9002 | 8961 | 203.7 | 203.7 | 134.7 | 0.0409 | 1.982 |
| 1968 | 0.04 | 8933 | 8864 | 355.2 | 355.2 | 238.5 | 0.0721 | 1.967 |
| 1969 | 0.04 | 8816 | 8794 | 351.9 | 351.9 | 312.9 | 0.072 | 1.941 |
| 1970 | 0.041 | 8777 | 8766 | 359.9 | 359.9 | 341.1 | 0.0738 | 1.932 |
| 1971 | 0.037 | 8759 | 8769 | 321.4 | 321.4 | 338.6 | 0.0659 | 1.928 |
| 1972 | 0.036 | 8776 | 8783 | 312.6 | 312.6 | 324.2 | 0.064 | 1.932 |
| 1973 | 0.034 | 8787 | 8794 | 302.3 | 302.3 | 312.8 | 0.0618 | 1.935 |
| 1974 | 0.033 | 8798 | 8806 | 287.1 | 287.1 | 300.3 | 0.0586 | 1.937 |
| 1975 | 0.037 | 8811 | 8800 | 324.2 | 324.2 | 305.9 | 0.0662 | 1.94 |
| 1976 | 0.047 | 8793 | 8758 | 408.3 | 408.3 | 349.5 | 0.0838 | 1.936 |
| 1977 | 0.045 | 8734 | 8726 | 395.8 | 395.8 | 382.5 | 0.0816 | 1.923 |
| 1978 | 0.043 | 8721 | 8727 | 370.9 | 370.9 | 381.6 | 0.0764 | 1.92 |
| 1979 | 0.063 | 8731 | 8670 | 545 | 545 | 439.9 | 0.113 | 1.922 |
| 1980 | 0.046 | 8626 | 8659 | 394.3 | 394.3 | 450.5 | 0.0819 | 1.899 |
| 1981 | 0.061 | 8683 | 8645 | 527.8 | 527.8 | 464.5 | 0.1098 | 1.912 |
| 1982 | 0.081 | 8619 | 8544 | 693.9 | 693.9 | 565.2 | 0.146 | 1.898 |
| 1983 | 0.079 | 8491 | 8471 | 670.4 | 670.4 | 636.4 | 0.1423 | 1.869 |
| 1984 | 0.069 | 8456 | 8482 | 582.4 | 582.4 | 625.6 | 0.1235 | 1.862 |
| 1985 | 0.061 | 8500 | 8532 | 520.8 | 520.8 | 576.5 | 0.1098 | 1.871 |
| 1986 | 0.044 | 8555 | 8620 | 379.9 | 379.9 | 489.9 | 0.0793 | 1.884 |
| 1987 | 0.06 | 8665 | 8639 | 515.8 | 515.8 | 470.8 | 0.1074 | 1.908 |
| 1988 | 0.097 | 8620 | 8497 | 820.1 | 820.1 | 610.2 | 0.1736 | 1.898 |
| 1989 | 0.087 | 8411 | 8397 | 728.5 | 728.5 | 706.1 | 0.156 | 1.852 |
| 1990 | 0.116 | 8388 | 8294 | 963 | 963 | 802.1 | 0.2088 | 1.847 |
| 1991 | 0.14 | 8227 | 8123 | 1135 | 1135 | 955.8 | 0.2513 | 1.811 |

| Year | Estimated Total F mort | Estimated Starting biomass | Estimated Average biomass | Observed Total yield | Model Total yield | Estimated Surplus production | Ratio F mort to Fmsy | Ratio biomass to Bmsy |
|---|---|---|---|---|---|---|---|---|
| 1992 | 0.185 | 8048 | 7876 | 1459 | 1459 | 1164 | 0.3332 | 1.772 |
| 1993 | 0.206 | 7753 | 7630 | 1570 | 1570 | 1358 | 0.37 | 1.707 |
| 1994 | 0.189 | 7541 | 7540 | 1426 | 1426 | 1425 | 0.34 | 1.66 |
| 1995 | 0.157 | 7540 | 7632 | 1196 | 1196 | 1356 | 0.2818 | 1.66 |
| 1996 | 0.144 | 7701 | 7774 | 1119 | 1119 | 1247 | 0.2588 | 1.695 |
| 1997 | 0.129 | 7829 | 7901 | 1018 | 1018 | 1144 | 0.2318 | 1.724 |
| 1998 | 0.146 | 7954 | 7932 | 1157 | 1157 | 1119 | 0.2623 | 1.751 |
| 1999 | 0.14 | 7916 | 7925 | 1110 | 1110 | 1125 | 0.252 | 1.743 |
| 2000 | 0.147 | 7931 | 7915 | 1160 | 1160 | 1133 | 0.2635 | 1.746 |
| 2001 | 0.133 | 7904 | 7937 | 1058 | 1058 | 1115 | 0.2396 | 1.74 |
| 2002 | 0.165 | 7961 | 7881 | 1298 | 1298 | 1161 | 0.2962 | 1.753 |
| 2003 | 0.184 | 7824 | 7737 | 1425 | 1425 | 1276 | 0.3311 | 1.722 |
| 2004 | 0.166 | 7675 | 7692 | 1280 | 1280 | 1311 | 0.2992 | 1.69 |
| 2005 | 0.191 | 7706 | 7642 | 1459 | 1459 | 1349 | 0.3434 | 1.696 |
| 2006 | 0.162 | 7596 | 7653 | 1243 | 1243 | 1341 | 0.292 | 1.672 |
| 2007 | 0.167 | 7694 | 7703 | 1288 | 1288 | 1303 | 0.3006 | 1.694 |
| 2008 | | 7709 | | | | | | 1.697 |

The respective graphs (Figure 1.3.4.3) showed a poor fit of the observed yield with the predicted yield in all gears.


**Fig. 1.3.4.3. Observed and predicted values of CPUE for the different fishing gears (i.e. trawls (OTB), purse-seines (PS), and small scale gears (GNS and LLS)) for bogue in GSA 20.**

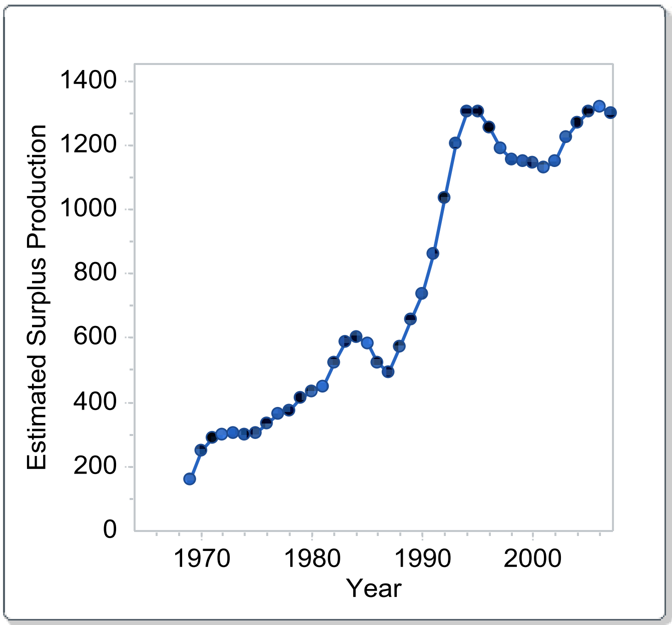


**Fig. 1.3.4.4. Estimated surplus production of bogue in GSA 22&23 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1964-2008.**

### 1.3.4.2 Method 2: SURBA

***Justification***

The relatively long time series of data available from the MEDITS surveys provided the most useful data sets for analysis. The survey-based stock assessment approach SURBA (Needle, 2003) was used on MEDITS (1994-2009) data for *Boops boops* in GSAs 20. Length was converted to ages based on the growth equation presented above and derived from Stergiou et al. (2004). Age groups 0 to 6 were identified in the specific length structure and ages 5 to 6 were merged as a plus group. Mean weight at age was a weighted mean based on the length frequency distribution of each age class. Average values were used for the years with missing info. Natural mortality was estimated as a vector for each age group based on ProdBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. Zero abundance values in those years where survey was carried out were replaced with 1 n/h as an indication of very low abundance. Bogue presents strong schooling behavior and a big fraction of the population occurs in the pelagic phase, not being accessible by the demersal trawl. This is especially true for the very young ages like 0 and 1 (Kalianiotis 1992). In addition the spatial distribution of the different ages varies depending on bathymetry thus affecting the catchability of the survey. Thus ages 0 and 1 were considered severely undersampled and excluded from the analysis. Ages 2 to 5+ were used for the analysis. Moreover the catchability of the survey was adjusted accordingly to 0.1, 0.8 and 0.9 for ages 2, 3 and 4 and 1 for age 5+.

***Input parameters***

**Tab. 1.3.4.1. MEDITS survey indexes (n/h) for *Boops boops* stock in GSA 20 standardized by haul duration.**

| **Survey indexes (n/h)** | Age 2 | Age 3 | Age 4 | Age 5+ |
|---|---|---|---|---|
| 1994 | 0.16400 | 0.02000 | 0.01200 | 0.00200 |

| | | | | |
|---|---|---|---|---|
| 1995 | 0.18719 | 0.11166 | 0.00985 | 0.00164 |
| 1996 | 0.00114 | 0.00114 | 0.00114 | 0.00114 |
| 1997 | 0.00147 | 0.00147 | 0.00147 | 0.00147 |
| 1998 | 0.00078 | 0.00078 | 0.00078 | 0.00078 |
| 1999 | 0.00082 | 0.00082 | 0.00082 | 0.00082 |
| 2000 | 0.00157 | 0.00157 | 0.00079 | 0.00079 |
| 2001 | 0.00078 | 0.00466 | 0.00078 | 0.00078 |
| 2002 | -99 | -99 | -99 | -99 |
| 2003 | 0.00075 | 0.00075 | 0.00075 | 0.00075 |
| 2004 | 0.00081 | 0.00081 | 0.00081 | 0.00081 |
| 2005 | 0.00079 | 0.00079 | 0.00079 | 0.00079 |
| 2006 | 1.63710 | 0.54274 | 0.02419 | 0.00242 |
| 2007 | -99 | -99 | -99 | -99 |
| 2008 | 0.67728 | 0.16506 | 0.02221 | 0.00296 |

Not available data due to the lack of survey are indicated as -99.

**Tab. 1.3.4.1. Mean weight at age in the *Boops boops* stock in GSA 20**

| | Age 2 | Age 3 | Age 4 | Age 5+ |
|---|---|---|---|---|
| 1994 | 0.04262 | 0.06214 | 0.08266 | 0.08722 |
| 1995 | 0.04393 | 0.06472 | 0.08722 | 0.08722 |
| 1996 | 0.04281 | 0.06398 | 0.09248 | 0.09768 |
| 1997 | 0.04281 | 0.06398 | 0.09248 | 0.09768 |
| 1998 | 0.04281 | 0.06398 | 0.09248 | 0.09768 |
| 1999 | 0.04281 | 0.06398 | 0.09248 | 0.09768 |
| 2000 | 0.04281 | 0.06398 | 0.09248 | 0.09768 |
| 2001 | 0.04281 | 0.06398 | 0.09248 | 0.09768 |
| 2002 | 0.04281 | 0.06398 | 0.09248 | 0.09768 |
| 2003 | 0.04281 | 0.06398 | 0.09248 | 0.09248 |
| 2004 | 0.04281 | 0.06398 | 0.09248 | 0.09248 |
| 2005 | 0.04281 | 0.06398 | 0.09248 | 0.09248 |
| 2006 | 0.04237 | 0.06377 | 0.10048 | 0.10048 |
| 2007 | 0.04281 | 0.06398 | 0.09248 | 0.09768 |
| 2008 | 0.04231 | 0.0653 | 0.09955 | 0.09955 |

**Tab. 1.3.4.2. Growth parameters (Kallianiotis 1992) and length weight relationship applied in *Boops boops* stock in GSA 20 for 1994-2008.**

| **$L_\infty$** | **k** | **$t_0$** |
|---|---|---|
| 294 (mm) | 0.2 $y^{-1}$ | -1.49 y |

| Length-weight relationships | |
|---|---|
| **a** | **b** |
| 0.000005 | 3.137 |

**Tab. 1.3.4.3. Maturity ogive of *Boops boops* stock in GSA 20 for 1994-2008. Maturity at Age was based on GSA 18 estimates**

| Age 2 | Age 3 | Age 4 | Age 5+ |
|---|---|---|---|
| 0.93 | 1 | 1 | 1 |

**Tab. 1.3.4.4. Vector of natural mortality M of *Boops boops* stock in GSA 20 for 1994-2008.**

| Age 2 | Age 3 | Age 4 | Age5+ |
|---|---|---|---|
| 0.65965 | 0.60653 | 0.57771 | 1 |

***Results***

The residual plots of log catchabilities were high for ages 2, 3 and 5+ for the years 2004 to 2008.

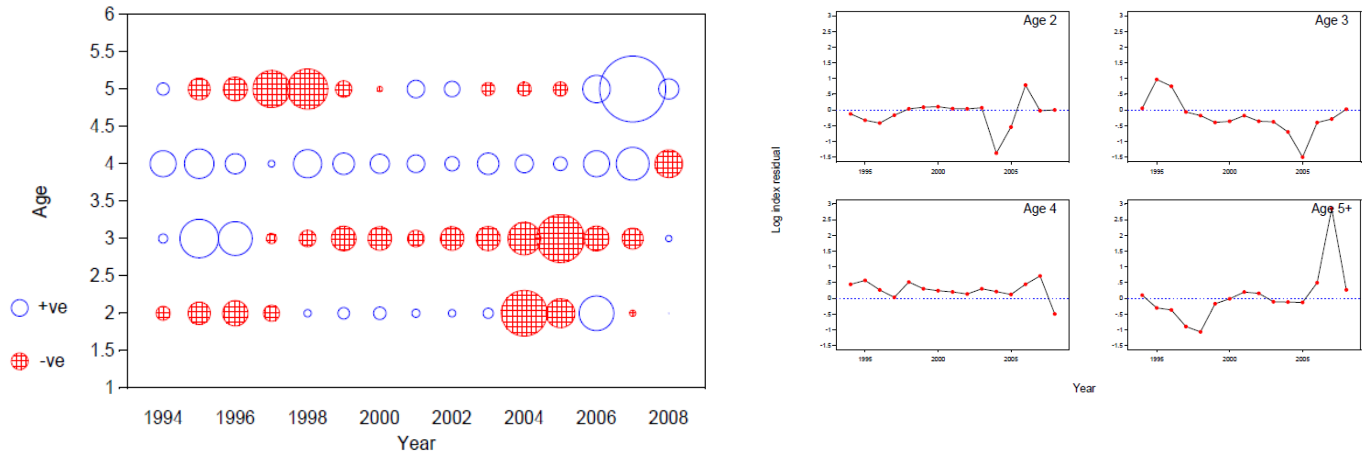


**Fig. 1.3.4.5. Residual plot of log index catchabilities per age and year of SURBA model for bogue in GSA 20 (1994-2008).**

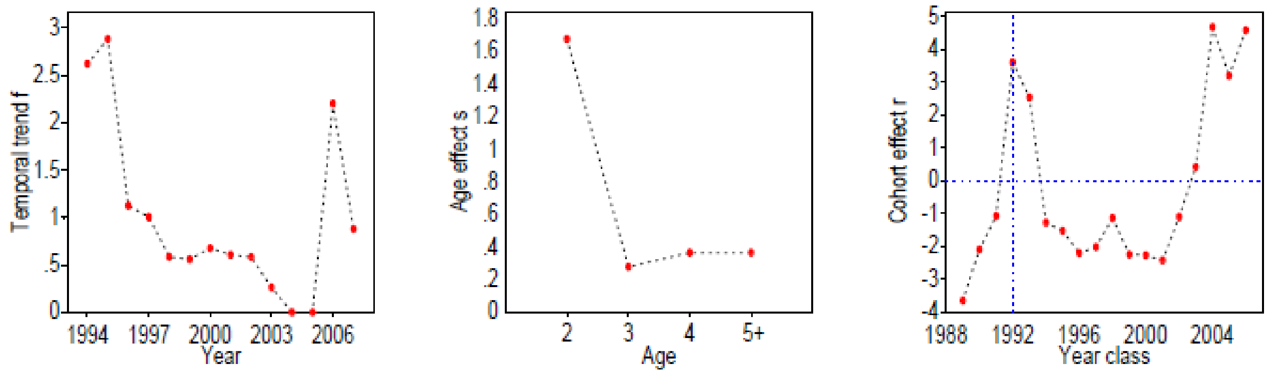


**Fig. 1.3.4.6. MEDITS survey. Fitted year, age and cohort effects estimated by SURBA.**

Fitted year effect, that is the model proxy for the combination of fishing effort and mean natural mortality in the underlying population, shows high fluctuations, presenting unexpected zero values in 2004 and 2005. Fitted age effect shows low values for ages 4 to 5+, while fitted cohort effect is highly variable showing an increasing trend after 2003 (Figure 1.3.4.6).

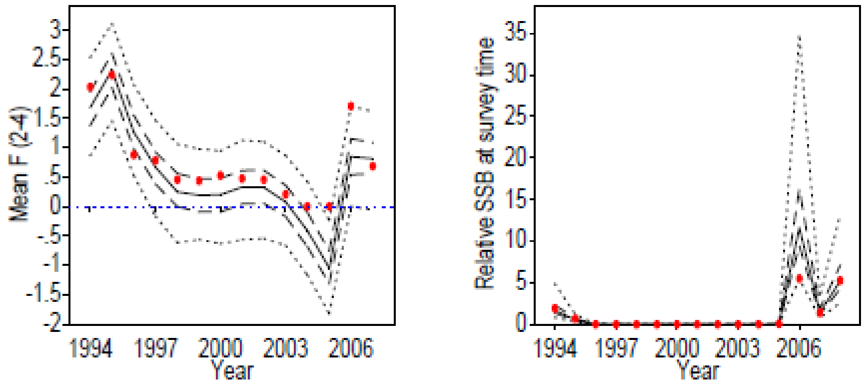


**Fig. 1.3.4.7. MEDITS survey. Estimated trend in F and relative SSB using SURBA.**

The model provides inconsistent estimates concerning the mean F and relative SSB. Extremely low values for the relative SSB from 1997 up to 2006 and similar values for mean F. This is largely due to very low survey index values for these years. Moreover it indicates that the assumed catchability pattern drives the estimates instead of the data themselves. However, these results are likely due to poor data fit and do not represent actual trends in mean F and relative SSB.

Model diagnostics are shown in the following Fig. 1.3.4.8 indicating poor data fit in most cohorts. Retrospective analysis was applied in the SURBA model for the 1994-2008 period with 8 years backward analysis. Results are presented in Fig. 1.3.4.9 showing retrospective bias in the case of temporal trend and age effect.

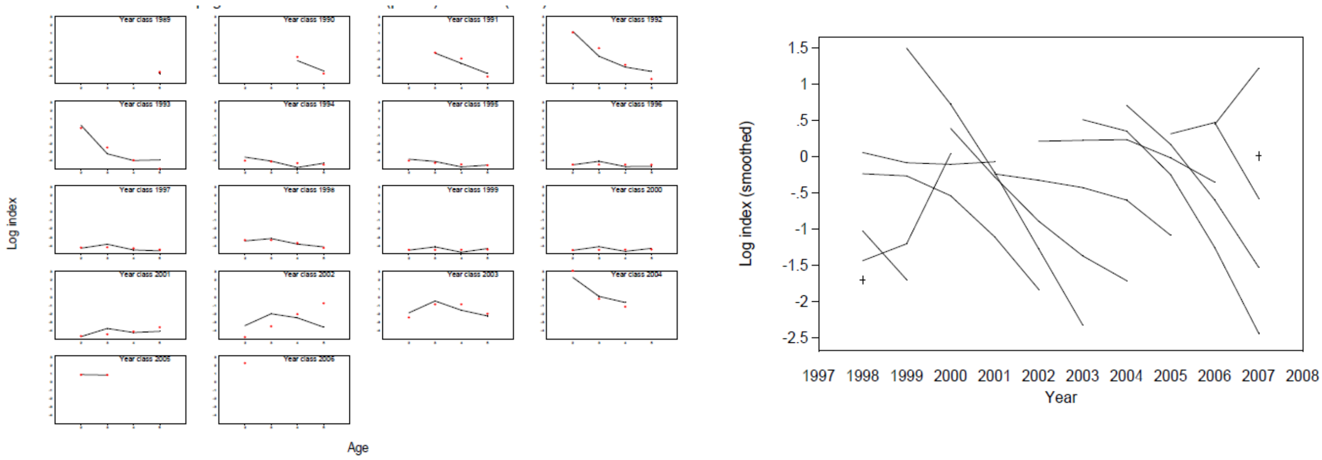


**Fig. 1.3.4.8. Model diagnostics for *Boops boops* SURBA model in the GSA 20 (MEDITS data). Left: Comparison between observed (points) and fitted (lines) survey abundance indices, for each year. Right: Log survey abundance indices by cohort. Each line represents the log index abundance of a particular cohort throughout its life.**

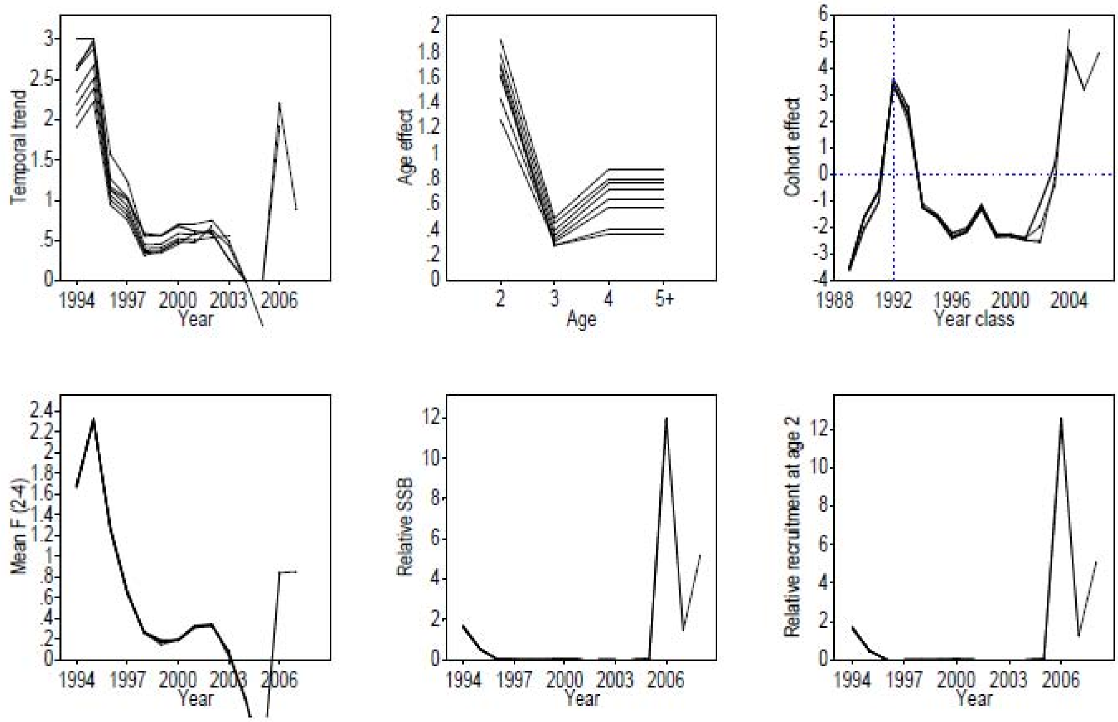


**Fig. 1.3.4.9. Model diagnostics for *Boops boops* SURBA model in the GSA 20 (MEDITS data). Results of retrospective analysis with 8 years period.**

### 1.3.5 *Long term prediction*

***Justification***

No long term prediction was done.

### 1.3.6 *Data quality*

No DCF data were available concerning landings, length and age structure of landings in GSA 20 that prevented the construction of a VPA based model like VIT or LCA. Survey data concerned MEDITS survey. Catches from MEDITS survey were quite inconsistent, coming from very few years. This makes the Working Group suggest that they were largely accidental preventing the construction of a reliable SURBA assessment model.

Data for the Surplus Production Model have derived from a reconsructed series back to 1964. No discards time series was available, so discards were not taken into account. Since the majority of landings for bogue in GSA 20 are coming from the artisanal vessels, operating within 1 nautical mile distance from the coast these landings are unlikely to be affected by neighborhood countries landings like Italy and Albania.

### 1.3.7 *Scientific advice*

#### 1.3.7.1 Short term considerations

***State of the spawning stock size***

In the absence of proposed or agreed references, STECF ad hoc Working Group is unable to fully evaluate the state of the stock and provide scientific advice.

The ASPIC model results are not considered reliable based on model fit.

No reliable estimates on the trend in the spawning stock size can be assessed based on SURBA results, which presented poor data fit.

The results of these analyses do not allow concluding on the status or trend of SSB and biomass.

***State of recruitment***

No reliable estimates on the state of recruitment can be assessed based on SURBA results that presented poor data fit.

***State of exploitation***

The ASPIC model results are not considered reliable based on model fit.

No reliable estimates on the trend in the spawning stock size can be assessed based on SURBA results, which presented poor fit of the data.

The results of these analyses do not allow concluding on the status or trend of F.

Additional data are needed, preferably data that can allow the implementation of a VPA based model, to fully evaluate stock status.

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## 1.4 **Stock assessment of bogue in GSA 22 & 23**

### 1.4.1 *Stock identification and biological features*

#### 1.4.1.1 Stock Identification

*Boops boops* (bogue) is a common Mediterranean fish species, commonly found on the shelf as coastal pelagic on various bottoms from 50 m down to 200 m depth (Kallianiotis 1992). It forms schools ascending close to the surface during the night. It is a sequential protogynous hermaphrodite fish, which displays sexual dimorphism during the reproductive period (Bauchot, and Hureau, 1986, Kallianiotis 1992). Kallianiotis (1992) showed that the dispersal of the species on the Cretan Continental shelf is characterised by seasonal fluctuations in the bathymetric distribution and the relative abundance of different length and age groups. Young fish are abundant in shallow coastal waters, older and bigger fish are being progressively more abundant as the depth increases up to 200 m where most fish are 3-4 years old. Migration between juvenile grounds to the feeding grounds of the adults in deeper waters and then back to shallow waters to spawn is characteristic of the life cycle of bogue. Especially bigger and older fish migrate towards deeper water during early summer.

#### 1.4.1.2 Growth

The von Bertalanffy growth parameters of bogue used were the ones estimated by Stergiou et al., (2004) i.e. $L_{inf}$=33.9 cm, k=0.17, to=-1.30 were utilized in the analyses of GSA 22&23. The estimation of these parameters was based on data from GSA 22 only.

Parameters of the length-weight relationship, related to combined sex, are: a=0.000005, b = 3.137 (for length expressed in mm) based on estimates of HCMR landing information.

#### 1.4.1.3 Maturity

The maturity ogive of the stock (sex combined), is presented in Table 1.4.1.1. Data used were collected under the Italian National Programme during 2006-2008 in GSA 18.

**Tab. 1.4.1.1. Maturity ogive data of *Boops boops*.**

| Age | 0 | 1 | 2 | 3 | 4 | 5+ |
|---|---|---|---|---|---|---|
| Prop. Mature | 0 | 0.1116 | 0.93 | 1 | 1 | 1 |

### 1.4.2 *Fisheries*

#### 1.4.2.1 General description of fisheries

During the years 1970-2008 the mean annual Mediterranean production of bogue was 26,000 tonnes. Approximately 10-20% of the total annual Mediterranean production of bogue is caught in Greek seas (FAO-FishStat, 2011, Fig.1.4.1.1). Bogue landings of Turkey coming from the Aegean Sea represent less than 5% of the entire basin landings and being almost half of the Greek landings.

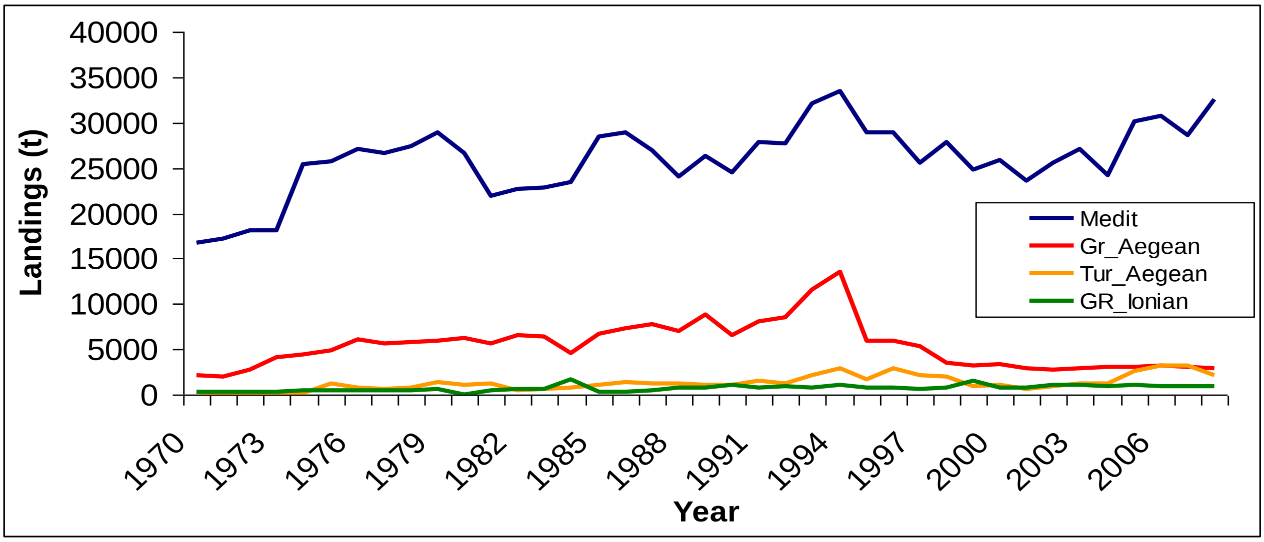



**Fig. 1.4.1.1. The evolution of bogue landings in the Mediterranean Sea and the Aegean Sea (Greek and Turkish landings).**

1.4.2.2 Management regulations applicable in 2010 and 2011

1.4.2.3 Catches

***Landings***

The landings of *Boops boops* for the period 1964-2008 in GSA 22&23 by the main fisheries are given in Figure 1.4.2.1. This info is based on data presented in Section 1, EVOMED data provided to the WG, data from Moutopoulos and Stergiou (2012) and data to FAO GFCM (see section 1 of this report for details). Small scale boats and purse seiners seem to be the ones responsible for the majority of bogue landings.

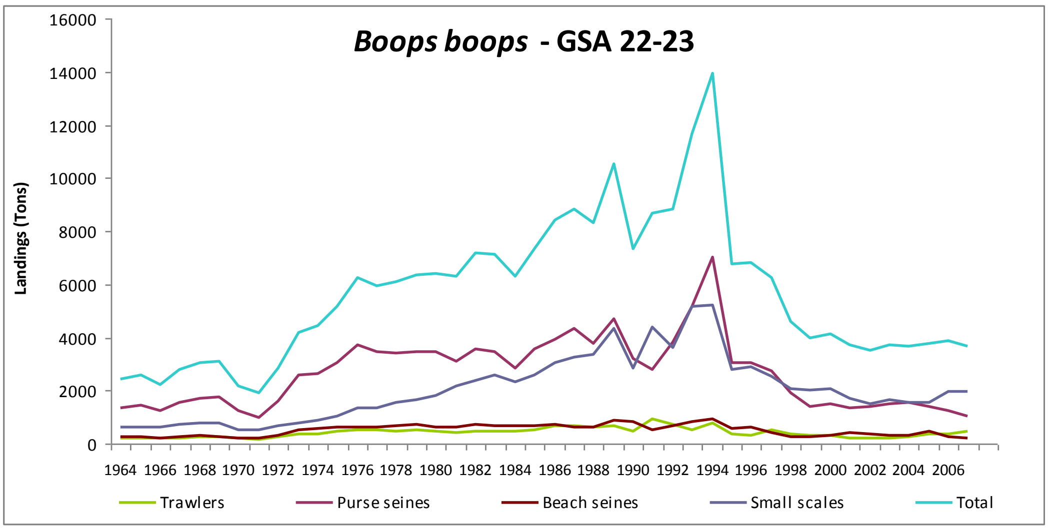


**Fig. 1.4.2.1. Landings of *B. boops* in GSA 22&23 (only Greek part concerning GSA 22) by fishing gear for the period 1964-2008.**

***Discards***

In Aegean Sea, it is known that purse seines can discard bogue to a ratio that approximates 28% of the annual bogue landings for the specific gear (Tsagarakis et al., 2012). Beach seines are reported to discard on average 12% of their bogue catches (Petrakis et al. 2009). No estimates are available for trawlers, however the $L_{50}$ for discards is around 11.7 cm (Machias et al 2007). Concerning the artisanal fishery, Tzanatos et al. (2007) report up to 37% of bogue discarded in Patraikos gulf in GSA 20.

***Fishing effort***

Fishing effort data in GSA 22-23 were provided according to the 2009 Official EC Data Call. Table 1.4.2.1 lists the reported effort for bottom trawler (OTB), small scale fishery (GTR and LLS), purse seine (PS) and beach seine (SB) in GSA 22&23.

**Tab. 1.4.2.1. Effort in GSA 22&23 expressed in (KW*DAYS)/1000, 2003-2008.**

| YEARS | GTR | LLS | OTB | PS | SB |
|---|---|---|---|---|---|
| **2003** | 68846 | 1888 | 15793 | 9389 | 2776 |
| **2004** | 70634 | 4977 | 15875 | 9141 | 2207 |
| **2005** | 70747 | 2716 | 17731 | 9656 | 2194 |
| **2006** | 66781 | 3848 | 16424 | 8993 | 2022 |
| **2008** | 50244 | 7915 | 16013 | 8234 | 1775 |

## 1.4.3 *Scientific surveys*

### 1.4.3.1 MEDITS

***Methods***

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 22&23 the following numbers of hauls were reported per depth stratum (Tab. 1.4.3.1).

**Tab. 1.4.3.1. Number of hauls per year and depth stratum in GSA 22&23.**

| Stratum | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2003 | 2004 | 2005 | 2006 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **010-050** | 10 | 10 | 11 | 10 | 13 | 12 | 12 | 13 | 13 | 13 | 14 | 12 | 13 |
| **050-100** | 17 | 21 | 22 | 28 | 23 | 26 | 22 | 25 | 25 | 23 | 24 | 26 | 26 |
| **100-200** | 19 | 25 | 37 | 36 | 37 | 33 | 37 | 35 | 36 | 43 | 41 | 41 | 40 |
| **200-500** | 28 | 35 | 44 | 50 | 51 | 51 | 50 | 48 | 51 | 52 | 52 | 52 | 52 |
| **500-800** | 18 | 12 | 19 | 21 | 22 | 21 | 20 | 17 | 17 | 16 | 17 | 16 | 17 |
| **TOTAL** | 92 | 103 | 133 | 145 | 146 | 143 | 141 | 138 | 142 | 147 | 148 | 147 | 148 |

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution and quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O’Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

***Geographical distribution patterns***

Figure 1.4.3.1 provides the distribution of sampling hauls of the MEDITS survey in GSA 22&23.

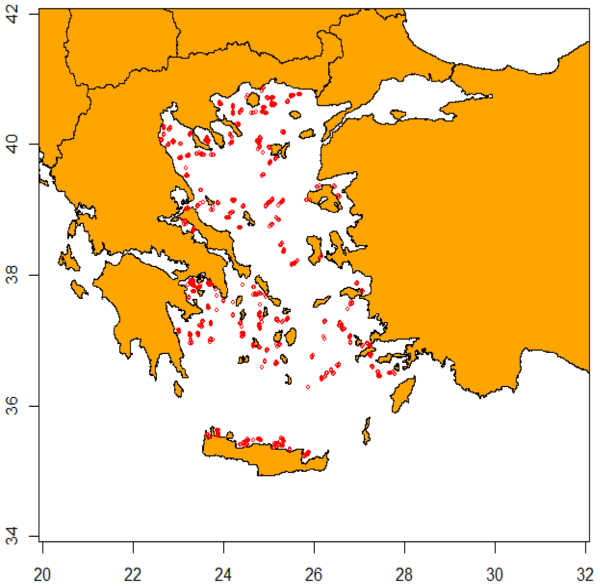



**Fig. 1.4.3.1. Distribution of sampling hauls of the MEDITS survey in GSA 22&23.**

***Trends in abundance and biomass***

Fishery independent information regarding the state of the bogue in GSA 22&23 was derived from the international survey MEDITS.

Figure 1.4.3.2 displays the estimated trend in bogue abundance and biomass in GSA 22&23. The estimated abundance index reveals very low numbers up to 2004 and a sharp increase afterwards.

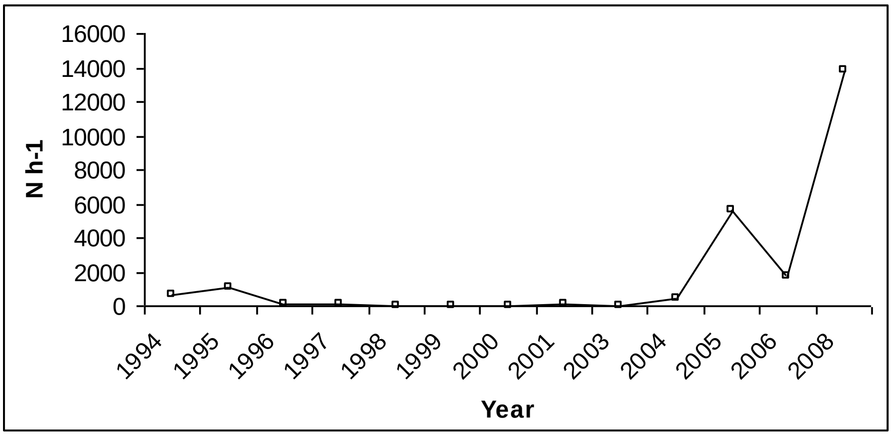



**Fig. 1.4.3.2. Abundance and biomass indices of bogue in GSA 22&23.**

***Trends in abundance by length or age***

The following Fig. 1.4.3.3-4 displays the stratified abundance indices of GSA 22&23 in 1994-2008.

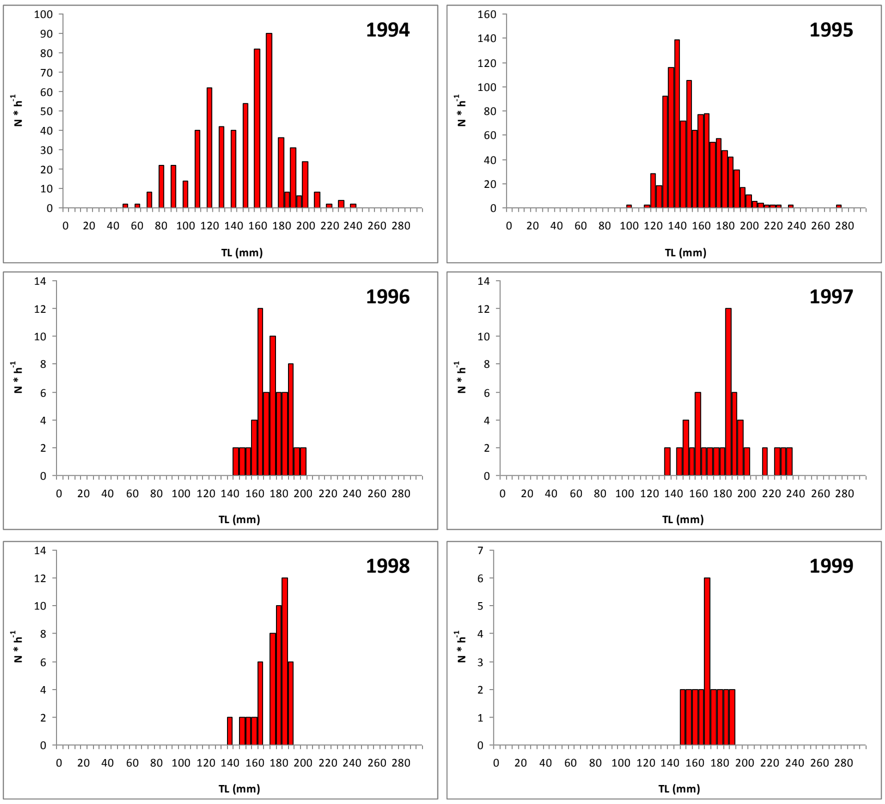



**Fig. 1.4.3.3. Stratified abundance indices by size of bogue in GSA 22&23, 1994-1999.**

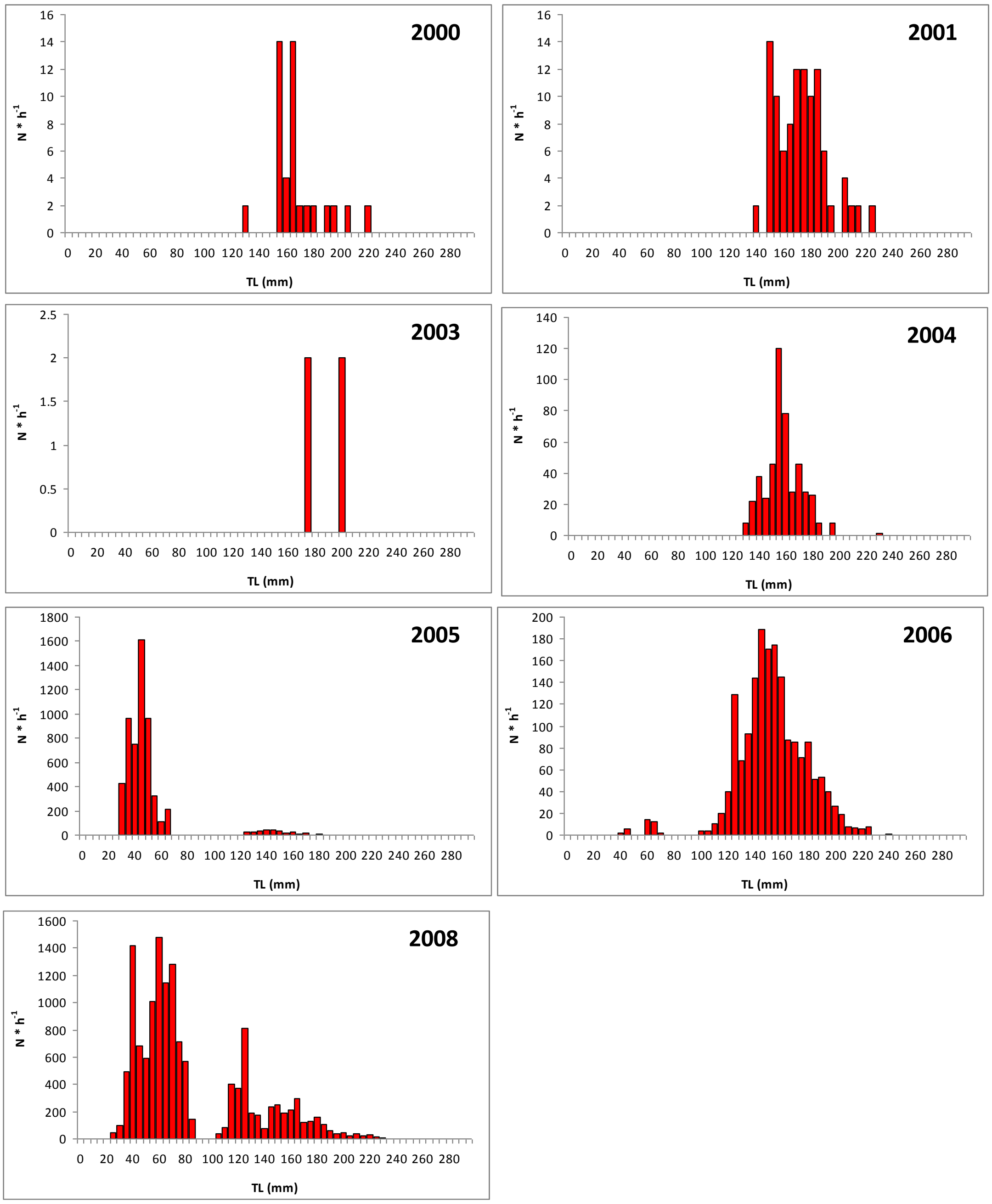



**Fig. 1.4.3.4. Stratified abundance indices by size of bogue in GSA 22&23, 2000-2008.**

## 1.4.4 *Assessment of historic stock parameters*

### 1.4.4.1 Method 1: Stock Production Model

***Justification***

A production model has been employed in order to estimate the fishing mortality and the biomass at sea and the relative reference points in term of $F_{MSY}$ and $B_{MSY}$, using the catch and effort data estimated as in section 1 of this report and by Moutopoulos and Stergiou (2012).

***Input parameters***

The analysis was performed using the ASPIC.5.3 software (A Stock-Production model Incorporating Covariates) (Prager, 1994, 2005) assuming a Schaefer (1954) model. This program implements a nonequilibrium, continuous-time, observation-error estimator for the dynamic production model (Schnute, 1977; Prager, 1994). The model was used to estimate K, MSY, the ratios of both current biomass or F to the biomass or F at which MSY can be attained, and q (the catchability coefficient, the proportion of total stock removed by one unit of fishing effort).

Input data consists of 3 sets of time series of total landings (in t) and standardized fishing effort expressed as fishing days * total HP for GSA 22&23 for the different fishing gears: purse-seines (PS), beach-seines (SV) and small scale (GNS and LLS) using the catch and effort data estimated as in section 1 of this report and by Moutopoulos and Stergiou (2012).

Data from trawls (OTB) were not used because of their small participation in the total landings. The possibility of using at the same time several data sets is a new extension incorporated in the ASPIC new versions.

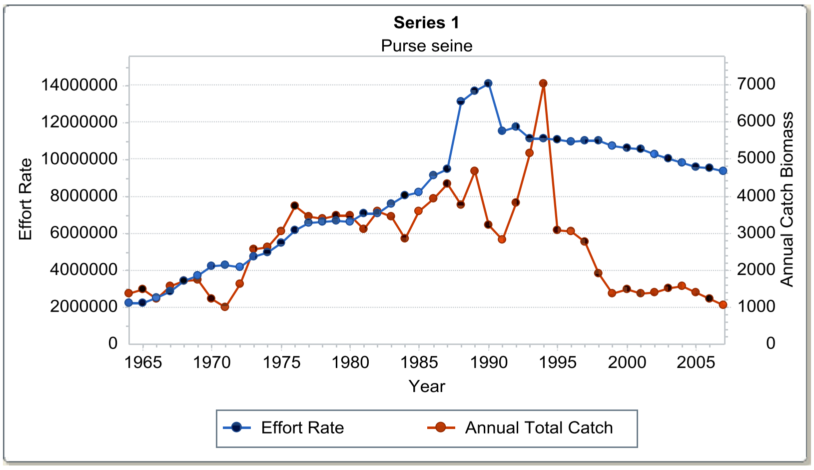
In addition to data on catch and effort, ASPIC requires starting guesses and ranges for the parameters to be estimated by the model: carrying capacity (K), maximum sustainable yield (MSY), the ratio of the biomass at the beginning of the first year to the carrying capacity (B1/K) and catchability (q) (Table 1.4.4.1).

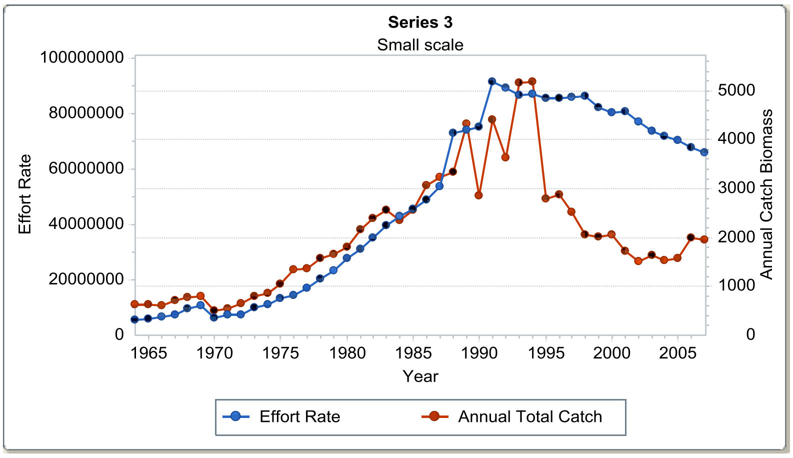
**Table 1.4.4.1. ASPIC input parameters of the FIT mode for bogue in GSA 22&23.**

| B1/K | MSY | Range of MSY | K | Range of K | Fishing fleet | q<br>(mean (CPUE) / 2*max(Y)) |
|---|---|---|---|---|---|---|
| 0.85 | 6000 | 2000 - 15000 | 20000 | 10000 - 40000 | Beach seine | 5.8441E-08 |
| | | | | | Purse seine | 5.4707E-08 |
| | | | | | Small scale | 5.2130E-08 |

After fitting the values for the above parameters, the FIT mode is run. At this point ASPIC computes estimates of parameters, including time trajectories of fishing intensity and stock biomass. The results of the fit were used to compute bias-corrected approximate confidence limits (80% CL) through bootstrap analysis. The model fittings are under the assumption that yield in each year is known more precisely than fishing effort or relative abundance from MEDITS survey, which has been discarded from the model because did not provide a better fit. In other words, all model fittings were conditioned on yield, rather than on effort or relative abundance (Prager 2005).

If there is normal convergence, the point estimates of the FIT mode were loaded in the BOT mode for bootstrapping. In this mode the software computes bootstrap confidence intervals on estimated quantities. This approach resamples the residuals from the optimum fit to generate new bootstrap samples of the observed time series. The residuals between the observed and predicted catch rates (CPUE), are used for bootstrap analysis. Bootstrap data sets are constructed by combining predicted CPUE with a randomly chosen residual to compute a pseudo-CPUE value. The model is then refit, using the pseudo-CPUE, which is assumed to relate back to stock biomass via the catchability coefficient (CPUE = qBt). The process is repeated at least 1000 times (bootstrap trials) for each different fit. At each trial the objective function used is the sum of squared errors (Haddon 2001, Prager 2005).



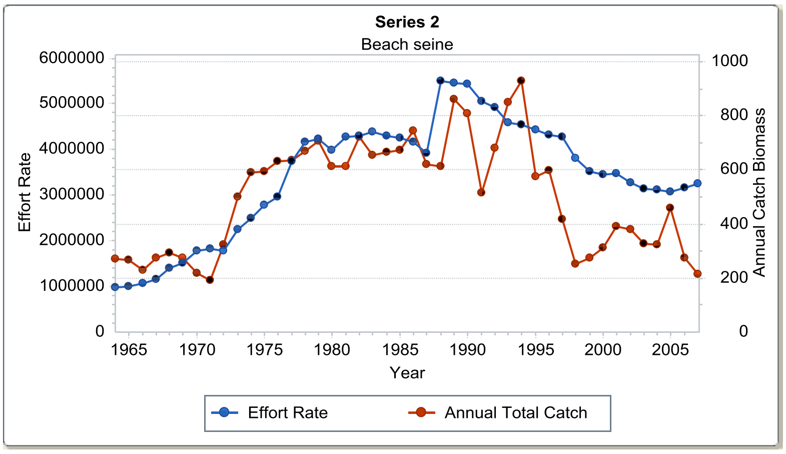




**Fig. 1.4.4.7. Input data for ASPIC for the different fishing gears (i.e. purse-seines (PS), and small scale gears (GNS and LLS)) for bogue in GSA 22&23.**

***Results***

Initial runs in the ASPIC FIT mode the logistic model gave normal convergence (Table 1.4.1.1 & Fig. 1.4.1.8). The observed CPUE and predicted CPUE indexes are shown in Figures 1.4.1.9. A clear decreasing trend in CPUEs is observed for all the fleets.

As follows the main results of the analysis for bogue in GSA 22&23 are shown below. The goodness of fit of each model is presented in Table 1.4.1.5.

**Table 1.4.4.1. ASPIC analysis for bogue in GSA 22&23.**

| | Weighted SSE | N | Weighted MSE | Current Weight | Inv Var weight | R-squared in CPUE |
|---|---|---|---|---|---|---|
| Loss component number and title | | | | | | |
| Loss(-1) SSE in yield | 0.00E+00 | | | | | |
| Loss(0) Penalty for B1 > K | 0.00E+00 | 1 | N/A | 1.00E+00 | N/A | |
| Loss(1) Purse seine | 1.51E+01 | 44 | 3.60E-01 | 1.82E+00 | 9.02E-01 | 0.411 |
| Loss(2) Beach seine | 3.84E+00 | 44 | 9.15E-02 | 2.73E-01 | 5.32E-01 | 0.604 |
| Loss(3) Small scale | 4.35E+00 | 44 | 1.04E-01 | 9.09E-01 | 1.57E+00 | 0.808 |
| | | | | | | |
| TOTAL OBJECTIVE FUNCTION, MSE, RMSE: | 2.33E+01 | | 0.18 49 | 4.30E-01 | | |
| Estimated contrast index (ideal = 1.0): | 0.8837 | | C* = (Bmax-Bmin)/K | | | |
| | | | | | | |
| Estimated nearness index (ideal = 1.0): | 1 | | N* = 1 - \|μιν(B-Bμσυ)\|/K | | | |

The estimates of MSY, $B_{MSY}$, $F_{MSY}$, $f_{MSY}$ (effort related MSY) for each fleet are shown in Table 1.4.1.6. The estimates of MSY and $F_{MSY}$ ranges after bootstrapping using approximate 80% upper and lower confidence limits are shown in Table 1.4.1.7. The results of the production model suggest that bogue in the GSA 22&23 is exploited sustainably ($F/F_{MSY}$ in 2007=0.616). The $F/F_{MSY}$ exhibits an increasing trend since 1994. The $B_{MSY}$ (current $B_{curr}/B_{MSY}$ in 2008) is 0.889 exhibiting a declining trend since 2003.

**Table 1.4.4.2. Estimated parameters of bogue in GSA 22 and 23.**

| Model | MSY (tons) | $B_{MSY}$ (tons) | $F_{MSY}$ | $f_{MSY}$ Beach seine | $f_{MSY}$ Purse seine | $f_{MSY}$ Small scale |
|---|---|---|---|---|---|---|
| **Logistic** | 8210 | 12640 | 0.649 | 5.684E+07 | 2.535E+07 | 1.691E+08 |

**Table 1.4.4.3. Estimates of MSY and $F_{MSY}$ from bootstrapped analysis in ASPIC with confidence limits.**

| Model | MSY | | | $F_{MSY}$ | | |
|---|---|---|---|---|---|---|
| | 80% lower | | 80% higher | 80% lower | | 80% higher |
| **Logistic** | 7896 | 8210 | 8431 | 0.528 | 0.649 | 0.747 |

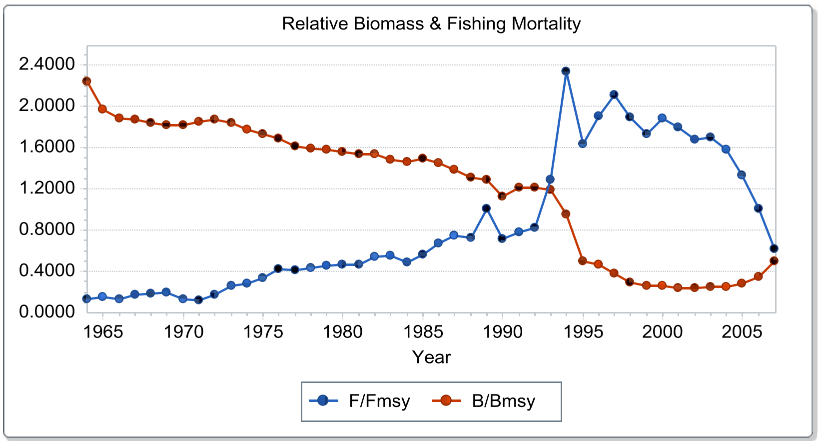


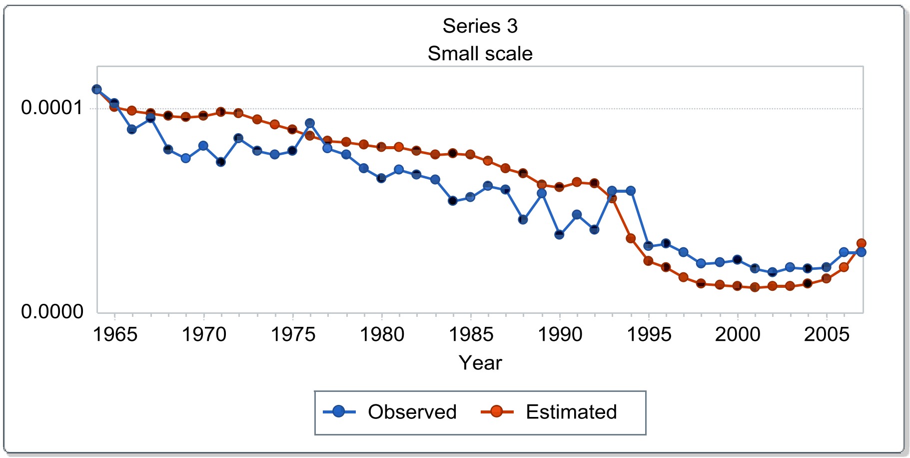

**Fig. 1.4.4.1. Historic trend in estimated fishing mortality as $F/F_{MSY}$ ratio and biomass as $B/B_{MSY}$ ratio.**

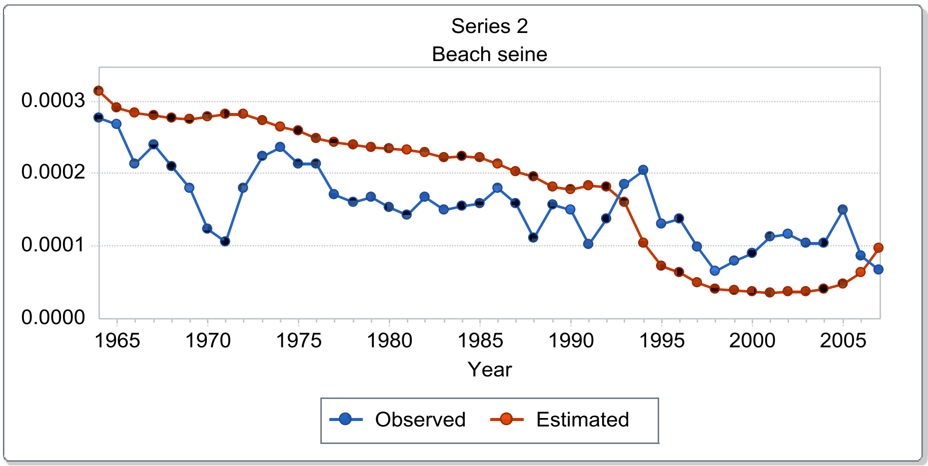
**Table 1.4.4.4. Estimated Population Trajectory.**

| Year | Estimated Total F mort | Estimated Starting biomass | Estimated Average biomass | Observed Total yield | Model Total yield | Estimated Surplus production | Ratio F mort to Fmsy | Ratio biomass to Bmsy |
|---|---|---|---|---|---|---|---|---|
| 1964 | 1964 | 0.092 | 2.53E+04 | 2.45E+04 | 2.25E+03 | 2.25E+03 | 9.56E+02 | 1.41E-01 |
| 1965 | 1965 | 0.099 | 2.40E+04 | 2.37E+04 | 2.36E+03 | 2.36E+03 | 1.89E+03 | 1.53E-01 |
| 1966 | 1966 | 0.087 | 2.35E+04 | 2.36E+04 | 2.05E+03 | 2.05E+03 | 2.08E+03 | 1.34E-01 |
| 1967 | 1967 | 0.109 | 2.36E+04 | 2.34E+04 | 2.55E+03 | 2.55E+03 | 2.26E+03 | 1.68E-01 |
| 1968 | 1968 | 0.12 | 2.33E+04 | 2.31E+04 | 2.79E+03 | 2.79E+03 | 2.55E+03 | 1.85E-01 |
| 1969 | 1969 | 0.123 | 2.30E+04 | 2.30E+04 | 2.82E+03 | 2.82E+03 | 2.72E+03 | 1.89E-01 |
| 1970 | 1970 | 0.083 | 2.29E+04 | 2.32E+04 | 1.93E+03 | 1.93E+03 | 2.44E+03 | 1.28E-01 |
| 1971 | 1971 | 0.074 | 2.34E+04 | 2.36E+04 | 1.74E+03 | 1.74E+03 | 2.02E+03 | 1.13E-01 |
| 1972 | 1972 | 0.11 | 2.37E+04 | 2.35E+04 | 2.58E+03 | 2.58E+03 | 2.17E+03 | 1.69E-01 |
| 1973 | 1973 | 0.17 | 2.33E+04 | 2.28E+04 | 3.86E+03 | 3.86E+03 | 2.94E+03 | 2.61E-01 |
| 1974 | 1974 | 0.185 | 2.24E+04 | 2.21E+04 | 4.08E+03 | 4.08E+03 | 3.60E+03 | 2.84E-01 |
| 1975 | 1975 | 0.218 | 2.19E+04 | 2.16E+04 | 4.70E+03 | 4.70E+03 | 4.11E+03 | 3.36E-01 |
| 1976 | 1976 | 0.274 | 2.13E+04 | 2.08E+04 | 5.70E+03 | 5.70E+03 | 4.79E+03 | 4.22E-01 |
| 1977 | 1977 | 0.268 | 2.04E+04 | 2.03E+04 | 5.44E+03 | 5.44E+03 | 5.21E+03 | 4.13E-01 |
| 1978 | 1978 | 0.281 | 2.02E+04 | 2.01E+04 | 5.64E+03 | 5.64E+03 | 5.39E+03 | 4.33E-01 |
| 1979 | 1979 | 0.294 | 2.00E+04 | 1.98E+04 | 5.82E+03 | 5.82E+03 | 5.58E+03 | 4.53E-01 |
| 1980 | 1980 | 0.301 | 1.97E+04 | 1.96E+04 | 5.90E+03 | 5.90E+03 | 5.72E+03 | 4.63E-01 |
| 1981 | 1981 | 0.301 | 1.95E+04 | 1.95E+04 | 5.87E+03 | 5.87E+03 | 5.80E+03 | 4.64E-01 |
| 1982 | 1982 | 0.35 | 1.95E+04 | 1.91E+04 | 6.68E+03 | 6.68E+03 | 6.07E+03 | 5.39E-01 |
| 1983 | 1983 | 0.358 | 1.88E+04 | 1.87E+04 | 6.67E+03 | 6.67E+03 | 6.35E+03 | 5.51E-01 |
| 1984 | 1984 | 0.313 | 1.85E+04 | 1.88E+04 | 5.87E+03 | 5.87E+03 | 6.29E+03 | 4.82E-01 |
| 1985 | 1985 | 0.366 | 1.89E+04 | 1.87E+04 | 6.82E+03 | 6.82E+03 | 6.35E+03 | 5.63E-01 |
| 1986 | 1986 | 0.432 | 1.85E+04 | 1.79E+04 | 7.74E+03 | 7.74E+03 | 6.78E+03 | 6.65E-01 |
| 1987 | 1987 | 0.483 | 1.75E+04 | 1.70E+04 | 8.19E+03 | 8.19E+03 | 7.25E+03 | 7.43E-01 |
| 1988 | 1988 | 0.47 | 1.66E+04 | 1.64E+04 | 7.71E+03 | 7.71E+03 | 7.47E+03 | 7.23E-01 |
| 1989 | 1989 | 0.65 | 1.63E+04 | 1.52E+04 | 9.87E+03 | 9.87E+03 | 7.86E+03 | 1.00E+00 |
| 1990 | 1990 | 0.46 | 1.43E+04 | 1.49E+04 | 6.87E+03 | 6.87E+03 | 7.94E+03 | 7.09E-01 |
| 1991 | 1991 | 0.5 | 1.54E+04 | 1.54E+04 | 7.73E+03 | 7.73E+03 | 7.81E+03 | 7.71E-01 |
| 1992 | 1992 | 0.53 | 1.55E+04 | 1.53E+04 | 8.11E+03 | 8.11E+03 | 7.84E+03 | 8.15E-01 |
| 1993 | 1993 | 0.827 | 1.52E+04 | 1.35E+04 | 1.11E+04 | 1.11E+04 | 8.14E+03 | 1.27E+00 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1994 | 1994 | 1.51 | 1.22E+04 | 8.72E+03 | 1.32E+04 | 1.32E+04 | 7.28E+03 | 2.32E+00 |
| 1995 | 1995 | 1.056 | 6.31E+03 | 6.09E+03 | 6.43E+03 | 6.43E+03 | 6.00E+03 | 1.63E+00 |
| 1996 | 1996 | 1.23 | 5.89E+03 | 5.31E+03 | 6.52E+03 | 6.52E+03 | 5.44E+03 | 1.89E+00 |
| 1997 | 1997 | 1.368 | 4.81E+03 | 4.17E+03 | 5.70E+03 | 5.70E+03 | 4.51E+03 | 2.11E+00 |
| 1998 | 1998 | 1.233 | 3.62E+03 | 3.43E+03 | 4.22E+03 | 4.22E+03 | 3.85E+03 | 1.90E+00 |
| 1999 | 1999 | 1.122 | 3.25E+03 | 3.26E+03 | 3.66E+03 | 3.66E+03 | 3.69E+03 | 1.73E+00 |
| 2000 | 2000 | 1.222 | 3.28E+03 | 3.14E+03 | 3.84E+03 | 3.84E+03 | 3.57E+03 | 1.88E+00 |
| 2001 | 2001 | 1.172 | 3.01E+03 | 2.97E+03 | 3.49E+03 | 3.49E+03 | 3.41E+03 | 1.80E+00 |
| 2002 | 2002 | 1.092 | 2.94E+03 | 3.02E+03 | 3.29E+03 | 3.29E+03 | 3.45E+03 | 1.68E+00 |
| 2003 | 2003 | 1.102 | 3.10E+03 | 3.15E+03 | 3.47E+03 | 3.47E+03 | 3.58E+03 | 1.70E+00 |
| 2004 | 2004 | 1.008 | 3.21E+03 | 3.41E+03 | 3.43E+03 | 3.43E+03 | 3.83E+03 | 1.55E+00 |
| 2005 | 2005 | 0.826 | 3.60E+03 | 4.13E+03 | 3.41E+03 | 3.41E+03 | 4.49E+03 | 1.27E+00 |
| 2006 | 2006 | 0.6 | 4.67E+03 | 5.81E+03 | 3.48E+03 | 3.48E+03 | 5.79E+03 | 9.23E-01 |
| 2007 | 2007 | 0.355 | 6.98E+03 | 9.11E+03 | 3.23E+03 | 3.23E+03 | 7.49E+03 | 5.46E-01 |
| 2008 | | | | 9.11E+03 | | | | 5.46E-01 |

Data of observed yield for bogue in GSA 22&23 shows a consistent fit with the predicted yield of the model for all gears throughout the time series (Fig. 1.4.4.2).



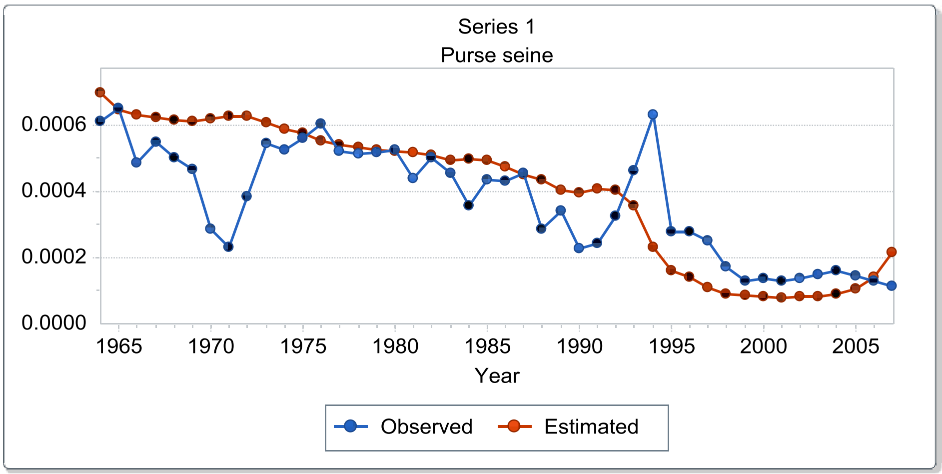



**Fig. 1.4.4.2. Observed and estimated yield for the different fishing gears (i.e. Series 1: purse-seines, PS, Series 2: beach-seines, SV, and Series 3: small scale gears, GNS and LLS) for bogue in GSA 22&23.**

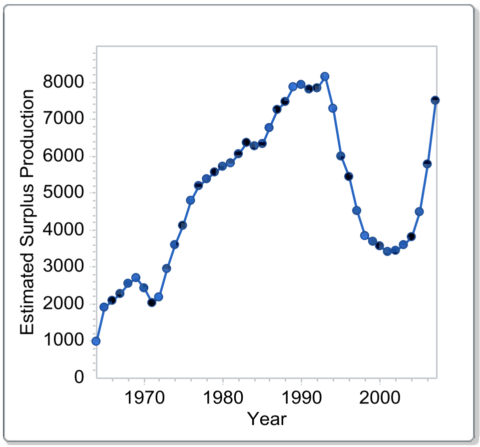



**Fig. 1.4.4.3. Estimated surplus production of bogue in GSA 22&23 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1964-2008.**

### 1.4.4.2 Method 2: SURBA

***Justification***

The relatively long time series of data available from the MEDITS surveys provided the most useful data sets for analysis. The survey-based stock assessment approach SURBA (Needle, 2003) was used on MEDITS (1994-2009) data for *Boops boops* in GSAs 22&23. Length was converted to ages based on the growth equation presented above and derived from Stergiou et al. (2004). Age groups 0 to 6 were identified in the specific length structure and ages 5 to 6 were merged as a plus group. Mean weight at age was a weighted mean based on the length frequency distribution of each age class. Average values were used for the years with missing info. Natural mortality was estimated as a vector for each age group based on ProdBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. Zero abundance values in those years where survey was carried out were replaced with 1 n/h as an indication of very low abundance. Bogue presents strong schooling behavior and a big fraction of the population occurs in the pelagic phase, not being accessible by the demersal trawl. This is especially true for the very young ages like 0 and 1 (Kalianiotis 1992). In addition the spatial distribution of the different ages varies depending on bathymetry and subsequently affecting the catchability of the survey. Thus ages 0 and 1 were considered severely undersampled and excluded from the analysis. Ages 2 to 5+ were used for the analysis. Moreover the catchability of the survey was adjusted accordingly to 0.1, 0.6 and 0.8 for ages 2, 3 and 4 and 1 for age 5+.

### *Input parameters*

**Table 1.4.4.5. MEDITS survey indexes (n/h) for bogue stock in GSA 22&23 standardized with haul duration.**

| **Survey indexes (n/h)** | Age 2 | Age 3 | Age 4 | Age 5+ |
|---|---|---|---|---|
| 1994 | 0.058962 | 0.021132 | 0.008349 | 0.002087 |
| 1995 | 0.087358 | 0.044835 | 0.004622 | 0.001849 |
| 1996 | 0.004599 | 0.00566 | 0.000354 | 0.000166 |
| 1997 | 0.002626 | 0.004266 | 0.000328 | 0.001313 |
| 1998 | 0.002016 | 0.006048 | 0.000168 | 0.000168 |
| 1999 | 0.002327 | 0.00133 | 0.000166 | 0.000166 |
| 2000 | 0.006047 | 0.001423 | 0.000356 | 0.000356 |
| 2001 | 0.009084 | 0.007631 | 0.00109 | 0.000727 |
| 2002 | -99 | -99 | -99 | -99 |
| 2003 | 0.000175 | 0.00035 | 0.00035 | 0.000168 |
| 2004 | 0.053571 | 0.011792 | 0.000168 | 0.000168 |
| 2005 | 0.01643 | 0.003765 | 0.001711 | 0.000171 |
| 2006 | 0.113298 | 0.051343 | 0.009242 | 0.003594 |
| 2007 | -99 | -99 | -99 | -99 |
| 2008 | 0.182807 | 0.082909 | 0.017159 | 0.013082 |

Not available data due to the lack of survey are indicated as -99.

**Table 1.4.4.6. Mean weight at age for the bogue stock in GSA 22&23.**

| | Age 2 | Age 3 | Age 4 | Age 5+ |
|---|---|---|---|---|
| 1994 | 0.040925 | 0.0675 | 0.08639 | 0.122858 |
| 1995 | 0.035232 | 0.057183 | 0.078438 | 0.114402 |
| 1996 | 0.056655 | 0.070375 | 0.070375 | 0.110932 |
| 1997 | 0.03854 | 0.058355 | 0.082244 | 0.096332 |
| 1998 | 0.027001 | 0.03854 | 0.082244 | 0.110932 |
| 1999 | 0.039406 | 0.059226 | 0.082244 | 0.110932 |
| 2000 | 0.041048 | 0.056351 | 0.082661 | 0.107024 |
| 2001 | 0.041432 | 0.064506 | 0.096332 | 0.110932 |
| 2002 | 0.039406 | 0.059226 | 0.082244 | 0.110932 |
| 2003 | 0.039406 | 0.059226 | 0.082244 | 0.110932 |
| 2004 | 0.037705 | 0.055076 | 0.082244 | 0.093404 |
| 2005 | 0.036054 | 0.058667 | 0.082244 | 0.110932 |
| 2006 | 0.035203 | 0.057591 | 0.070375 | 0.115336 |
| 2007 | 0.05163 | 0.060706 | 0.077068 | 0.10532 |
| 2008 | 0.043674 | 0.067339 | 0.091139 | 0.127166 |

**Table 1.4.4.7. Growth parameters (Stergiou et al., 2004) and length weight relationship applied in bogue stock in GSA 22&23 for 1994-2008.**

| $L_\infty$ | **k** | $t_0$ |
|---|---|---|
| 33.9 cm | 0.17 $y^{-1}$ | -1.30 y |
| Length-weight relationships | | |
| **a** | **b** | |

| | |
|---|---|
| 0.000005 | 3.137 |

**Table 1.4.4.8. Maturity ogive used for bogue stock in GSA 22&23 for 1994-2008. Estimates are based on maturity at age estimates in GSA 18.**

| Age 2 | Age 3 | Age 4 | Age 5+ |
|---|---|---|---|
| 0.93 | 1 | 1 | 1 |

**Tab. 1.4.4.9.Vector of natural mortality (M) for bogue stock in GSA 22-23 for 1994-2008.**

| Age 2 | Age 3 | Age 4 | Age 5+ |
|---|---|---|---|
| 0.659 | 0.606 | 0.577 | 0.545 |

***Results***

The residual plots of log catchabilities although higher for age 5+ do not present any apparent pattern (Fig. 1.4.4.4).

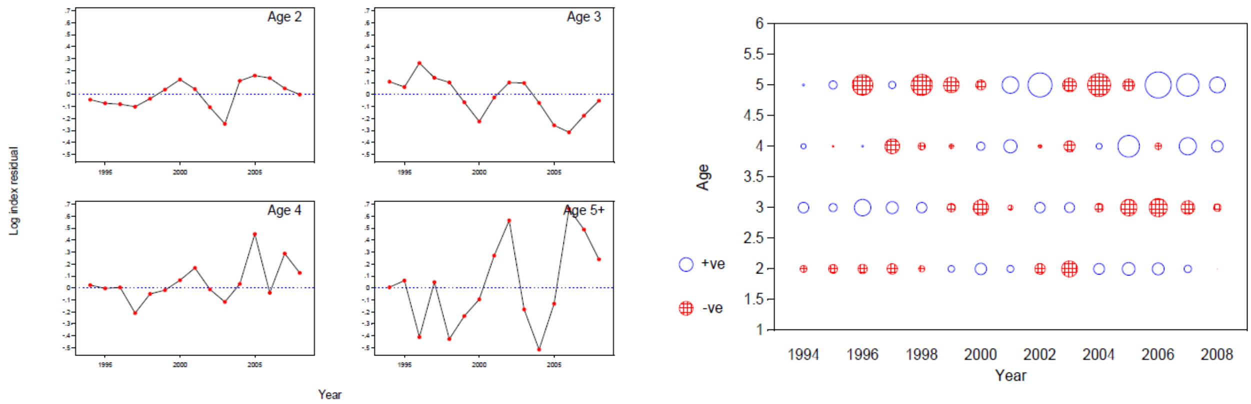



**Fig. 1.4.4.4. Residual plot of log index catchabilities per age and year of *Boops boops* SURBA model for GSA 22&23 (1994-2008).**

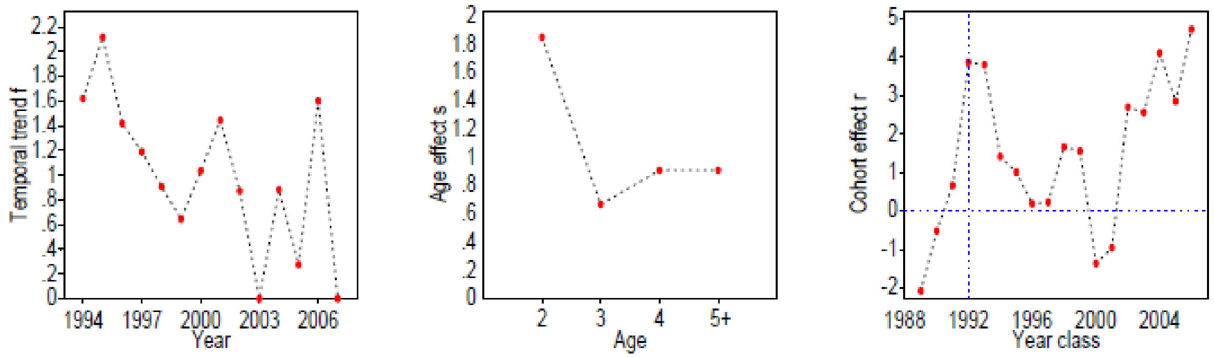



**Fig. 1.4.4.5. MEDITS survey. Fitted year, age and cohort effects estimated by SURBA.**

Fitted year effect, that is the model proxy for the combination of fishing effort and mean natural mortality in the underlying population, shows high fluctuations presenting a strange minimum in 2003 and 2006. Fitted age effect shows low values for ages 3 to 5+, while fitted cohort effect also shows a highly irregular pattern (Figure 1.4.4.5).

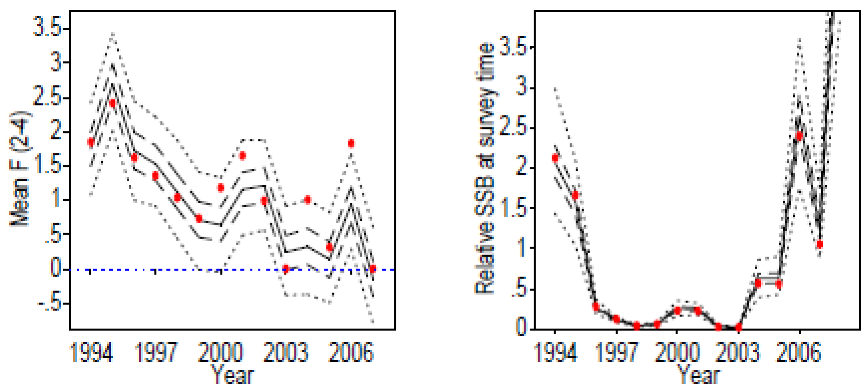
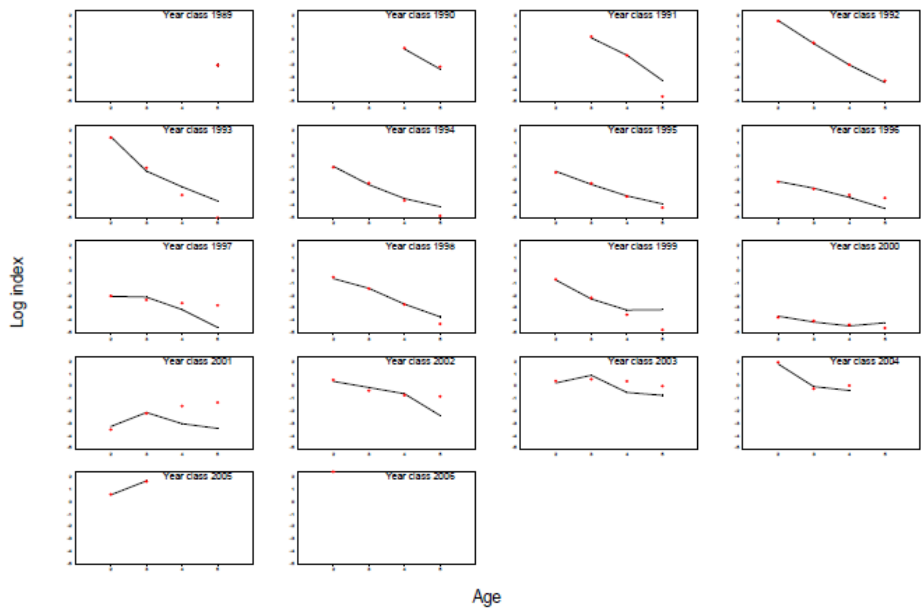



**Fig. 1.4.4.6. MEDITS survey. Estimated trend in F, relative SSB using SURBA.**

The model estimates a decreasing trend in mean F (ages 2-4). An increase in SSB is observed after 2003 (Fig. 1.4.4.6).

Model diagnostics are shown in the following Fig. 1.4.4.7 indicating poor data fit for certain cohorts. Retrospective analysis was applied in the SURBA model for the period 1994-2008 with 8 years backward analysis. Results are presented in Fig. 1.4.4.8 retrospective bias was identified in the case of temporal trend and age effect.
The assessment generally cannot be considered reliable since age cohorts present a poor fit, estimated index for F, SSB and recruitment are highly irregular. In addition the analysis is largely driven by the selected catchability pattern.



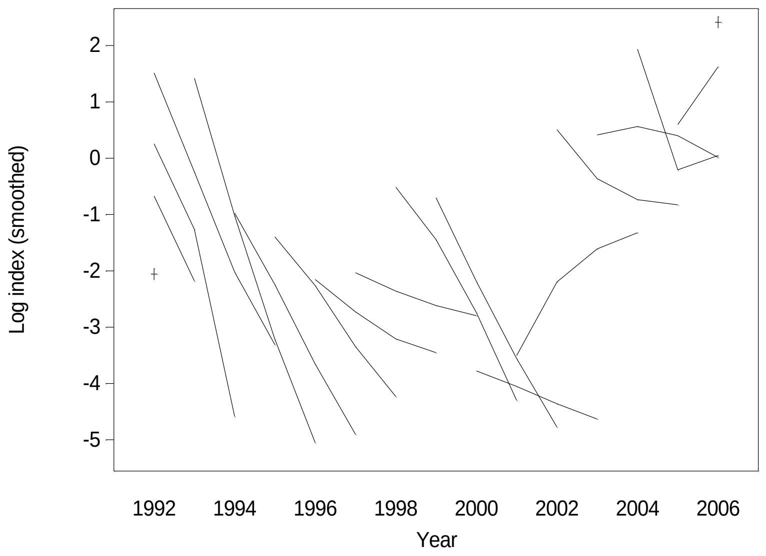



**Fig. 1.4.4.7. Model diagnostics for *Boops boops* SURBA model in the GSA 22&23 (MEDITS data). Left: Comparison between observed (points) and fitted (lines) survey abundance indices, for each year. Right: Log survey abundance indices by cohort. Each line represents the log index abundance of a particular cohort throughout its life.**

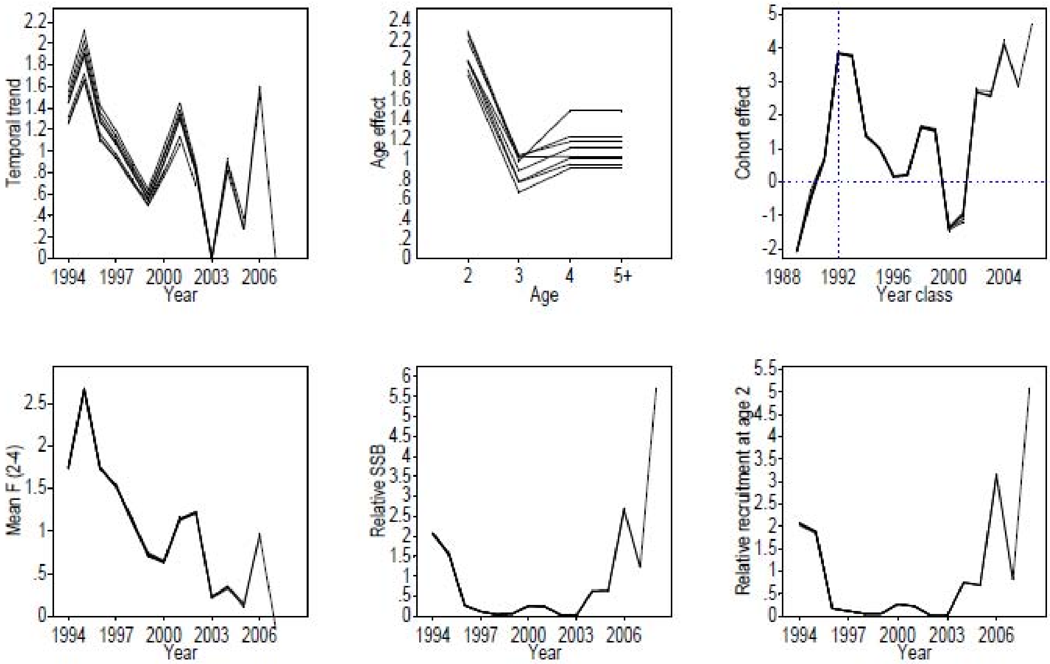



**Fig. 1.4.4.8. Model diagnostics for *Boops boops* SURBA model in the GSA 22&23 (MEDITS data). Results of retrospective analysis with an 8 years period.**

## 1.4.5 *Long term prediction*

### 1.4.5.1 Justification

No long term prediction was done.

The reference points estimated through the ASPIC production model are showed in Table 1.4.5.1.

**Table 1.4.5.1. Reference points estimated through production model.**

| | |
|---|---|
| Maximum sustainable yield (MSY; tons) | 8156 |
| Stock biomass giving MSY ($B_{MSY}$; tons) | 13010 |
| Fishing mortality rate at MSY ($F_{MSY}$) | 0.627 |

***Data quality***

No DCF data were available concerning landings, length and age structure of landings in GSA 22&23 that prevented the construction of a VPA based model like VIT or LCA. Survey data concerned MEDITS survey but these catches were quite inconsistent and the young age classes were clearly undersampled. This implies that catches were largely accidental preventing the construction of a reliable SURBA assessment model.

Data for the Surplus Production Model have derived from a reconsructed series back to 1964. No discards time series was available. The majority of landings for bogue in GSA 22&23 are coming from the artisanal vessels and purse seiners that operate mainly in close distance to the shore. Thus the landings of the specific stock can only partly be affected by Turkish landings. Turkish landings are expected to contribute only to the eastern part of Aegean Sea.

### 1.4.6 *Scientific advice*

#### 1.4.6.1 Short term considerations

***State of the spawning stock size***

In the absence of proposed or agreed precautionary refernce is not possible to fully evaluate the status of the spawning stock size. In the current stock assessment SURBA presented poor data fit so the resulting trend in the spawning stock biomass was not considered reliable. The lack of appropriate data from MEDITS survey and the lack of data after 2008 prevent the construction of a reliable and consistent SURBA model for assessment.

The current biomass estimated by the ASPIC model is 0.66 of $B_{MSY}$ ($B/B_{MSY}$ = 0.66), thus the current biomass is below the estimated biomass reference point for this stock.

***State of recruitment***

No reliable estimates on the state of recruitment can be assessed based on SURBA results. The lack of appropriate data from MEDITS survey and the lack of data after 2008 prevent the construction of a reliable and consistent SURBA model for assessment.

***State of exploitation***

The reference point estimated by ASPIC with the logistic model (0.35) suggests that bogue in GSA 22&23 is exploited sustainably ($F_{curr}/F_{MSY}$ in 2008=0.62).

Moreover, no reliable estimates on the state of the state of exploitation can be assessed based on SURBA results. The lack of appropriate data from MEDITS survey and the lack of data after 2008 prevent the construction of a reliable and consistent SURBA model for assessment.

Additional data are needed, preferably data that can allow a VPA based model, to fully evaluate stock status.

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## 1.5 **Stock assessment of picarel in GSA 20**

### 1.5.1 *Stock identification and biological features*

#### 1.5.1.1 Stock Identification

*Spicara smaris* (picarel) is a very common Mediterranean demersal fish and is important for the Mediterranean and the Greek fishery. It is a sequential protogynous hermaphrodite fish, which displays sexual dimorphism during the reproductive period (Zei, 1941, 1949; Tortonese, 1975; Whitehead et al., 1986). The lack of information on the biology of the species (e.g. distribution, dispersal, tagging experiments) may be due to the systematic confusion of the family Centracanthidae, which persisted until at least 1970 (Pollard and Pichot, 1971). The eggs of the picarel are demersal (Tortonese, 1975).

#### 1.5.1.2 Growth

The von Bertalanffy growth parameters of picarel used were the ones estimated by (Tsangridis, and Filippousis, 1991; Linf=19.6 cm, k=0.23, to=-1.97). The estimation of these parameters was based on data from GSA 23.

Parameters of the length-weight relationship, related to combined sex, are: a= 0.00002, b = 2.8439 (for length expressed in mm) based on estimates of HCMR landing information.

#### 1.5.1.3 Maturity

The maturity ogive of the stock (sex combined), as provided through the 2010 Official EC Data Call, is presented in Table 1.5.1.1. Data used were collected under the Cyprus National Programme during 2006-2008.

**Tab. 1.5.1.1. Maturity ogive data of *S. smaris*.**

| Age | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Prop. Mature | 0.79 | 0.85 | 0.90 | 0.85 | 0.97 | 0.96 |

### 1.5.2 *Fisheries*

#### 1.5.2.1 General description of fisheries

During the years 1970 - 2008 the mean annual Mediterranean production of the picarel was 13 000 tonnes. More than 50% of the total annual Mediterranean production was caught in Greek seas. In the ionian sea the avarage landing of picarel is around 1,500 tons (FAO-FISHSTAT GFCM database, 2011). The species in the Ionian sea is mainly caught by beach seines and trawlers, while only a small quantity is landed by the artisanal fishery and purse seine (see section 1 of this report and Moutoupolous and Stergiou (2012)), with landings comprised between 400 and 2,200 tons. The neighborhood countrys landings (Albania; FAO-FISHSTAT GFCM database) of picarel are quite low (on avarege around 5 tons in the last three years), so it is possible to assume that the stock inhabiting the GSA 20 is mainly exploited by the greek fleets.

### 1.5.2.2 Catches

***Landings***

The landings of *S. smaris* in GSA 20 by the main fisheries for the period 1964-2008 are given in Figure 1.5.2.1. The species has been mostly exploited by the beach seine and trawlers, with the maximum value observed in 1999. Since the data series presented by Moutoupolous and Stergiou (2012) ends in 2007, the amount of landing for each fleet in 2008 has been estimated using the total value presented in FAO-FISHSTAT GFCM database. Such amount has been allocated in each fleet on the basis of the proportion observed in 2007 in Moutoupolous and Stergiou (2012).

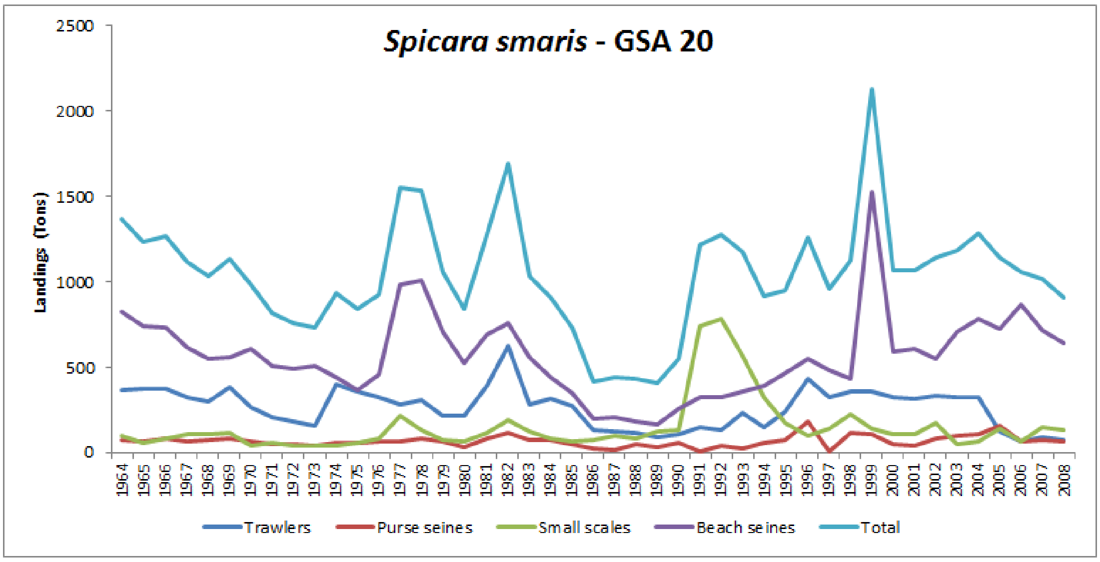



**Fig. 1.5.2.1. Landings of *S. smaris* in GSA 20 (Greece only) by fishing gear for the period 1964-2008.**

***Discards***

In Ionian Sea, it is known that picarel discards ratio for purse seines is 2% of the annual landings for the specific gear (Tsagarakis et al. 2012). Concerning the artisanal fishery Tzanatos et al. (2007) report that picarel is not discarded in Patraikos gulf (GSA 20). No estimates are available for trawlers, however the $L_{50}$ for discards is around 9.98 cm (Machias et al 2007). Because the lack of information for all the gears, the correction of 2% of discard of the purse seine was not taken into account.

***Fishing effort***

Fishing effort data in GSA 20 were provided according to the 2009 Official EC Data Call. Table 1.5.2.1. lists the reported effort for bottom trawler (OTB), small scale fishery (GTR and LLS), purse seine (PS) and beach seine (SB) in GSA 20.

**Tab. 1.5.2.1. Effort in GSA 20 expressed in (KW*DAYS)/1000, 2003-2008.**

| YEARS | GTR | LLS | OTB | PS | SB |
|---|---|---|---|---|---|
| **2003** | 37179 | 136 | 2957 | 836 | 960 |
| **2004** | 29272 | 748 | 2947 | 1002 | 774 |
| **2005** | 28537 | 454 | 2171 | 984 | 673 |
| **2006** | 22658 | 1396 | 2597 | 821 | 692 |
| **2008** | 21343 | 3983 | 2342 | 776 | 896 |

### 1.5.3 *Scientific surveys*

#### 1.5.3.1 MEDITS

***Methods***

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 20 the following numbers of hauls were reported per depth stratum (Tab. 1.5.3.1).

**Tab. 1.5.3.1. Number of hauls per year and depth stratum in GSA 20.**

| Stratum | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2003 | 2004 | 2005 | 2006 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **010-050** | 1 | 2 | 2 | 2 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **050-100** | 3 | 4 | 8 | 7 | 11 | 10 | 11 | 9 | 10 | 10 | 10 | 9 | 10 |
| **100-200** | 1 | 3 | 4 | 2 | 5 | 6 | 5 | 6 | 6 | 6 | 5 | 6 | 6 |
| **200-500** | 2 | 3 | 4 | 4 | 7 | 7 | 7 | 8 | 8 | 9 | 8 | 8 | 7 |
| **500-800** | 1 | 2 | 4 | 3 | 5 | 5 | 5 | 5 | 5 | 3 | 5 | 4 | 6 |
| **TOTAL** | 8 | 14 | 22 | 18 | 32 | 31 | 31 | 31 | 32 | 31 | 31 | 30 | 32 |

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution and quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).
Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

***Geographical distribution patterns***

Figure 1.5.3.1 provides the distribution of sampling hauls of the MEDITS survey in GSA 20.

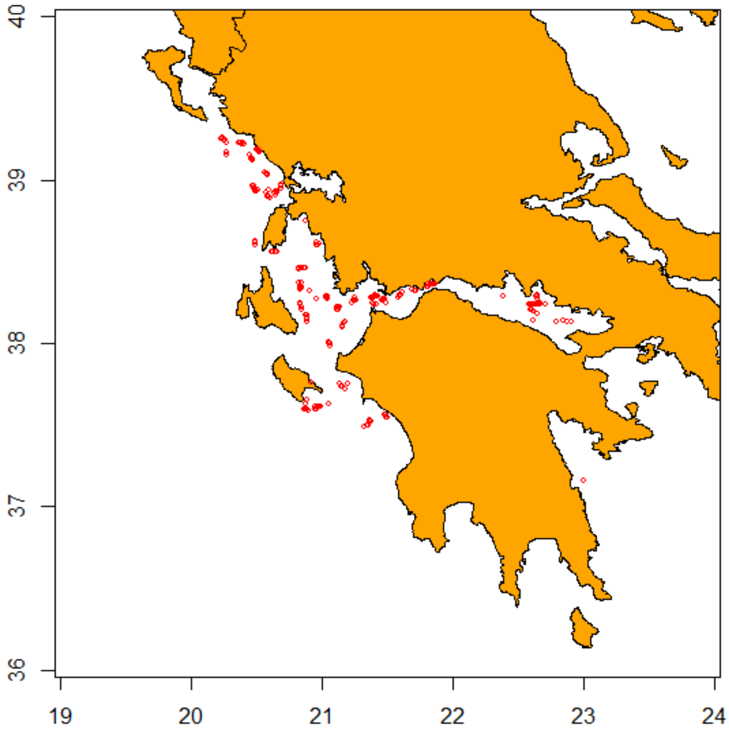



**Fig. 1.5.3.1 Distribution of sampling hauls of the MEDITS survey in GSA 20.**

***Trends in abundance and biomass***

Fishery independent information regarding the state of the picarel in GSA 20 was derived from the international survey MEDITS.

Figure 1.5.3.2 displays the estimated trend in picarel abundance and biomass in GSA 20. The estimated abundance and biomass indices reveal general increase both in number and in biomass. This trend seems to be in agreement with the trend in the landings during the same period (see Figures 1.5.2.1).

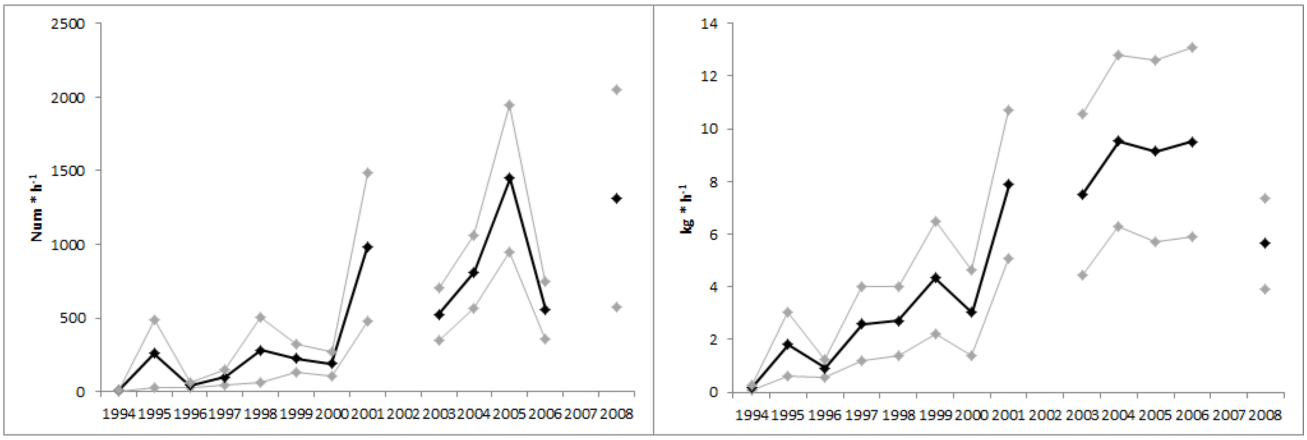



**Fig. 1.5.3.2. Abundance and biomass indices of picarel in GSA 20.**

***Trends in abundance by length or age***

The following Fig. 1.5.3.3-4 displays the stratified abundance indices of GSA 20 in 1994-2008.

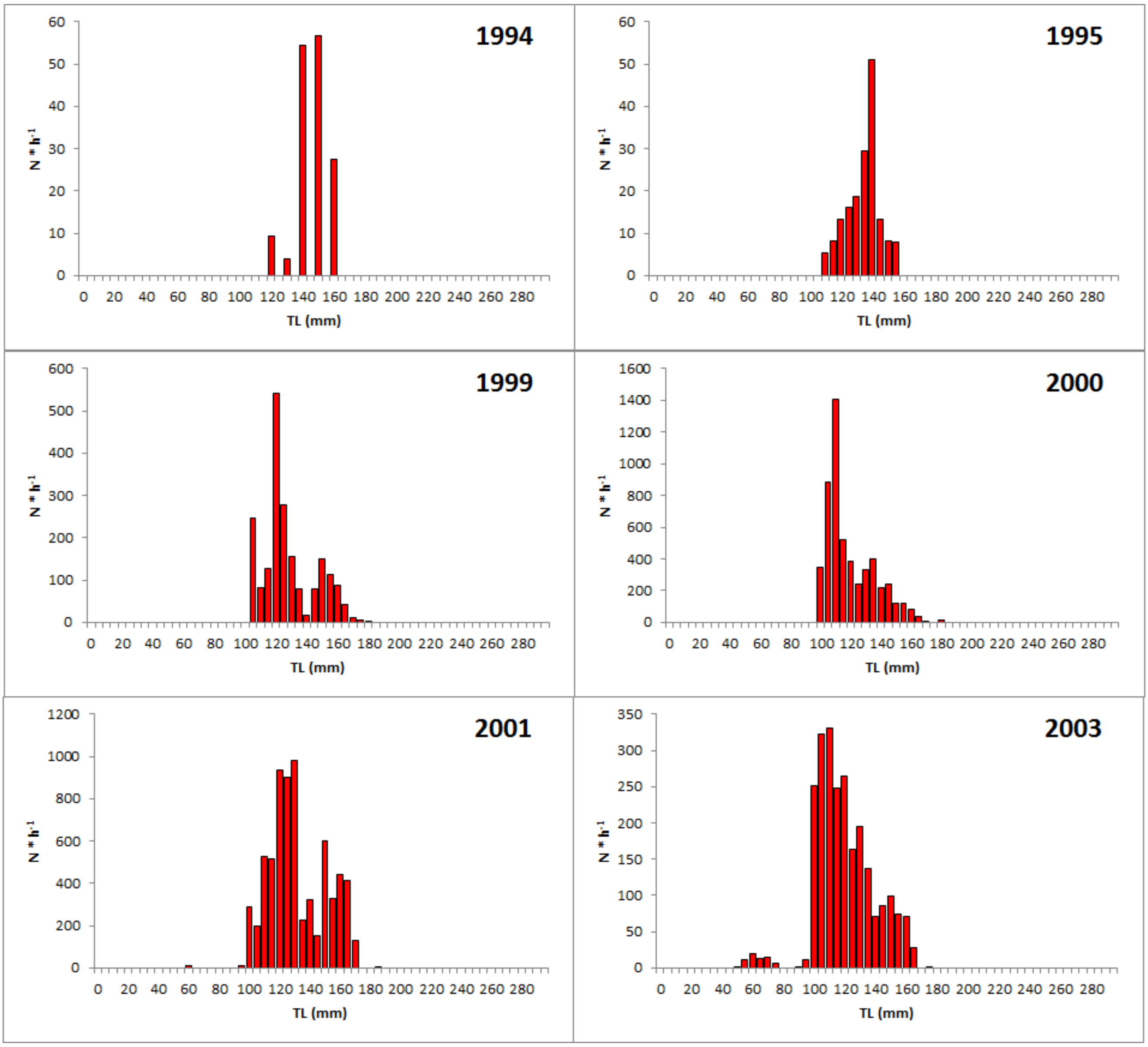



**Fig. 1.5.3.3. Stratified abundance indices by size of picarel in GSA 20, 1994-2003 (no length data for 1996, 1997, 1998).**

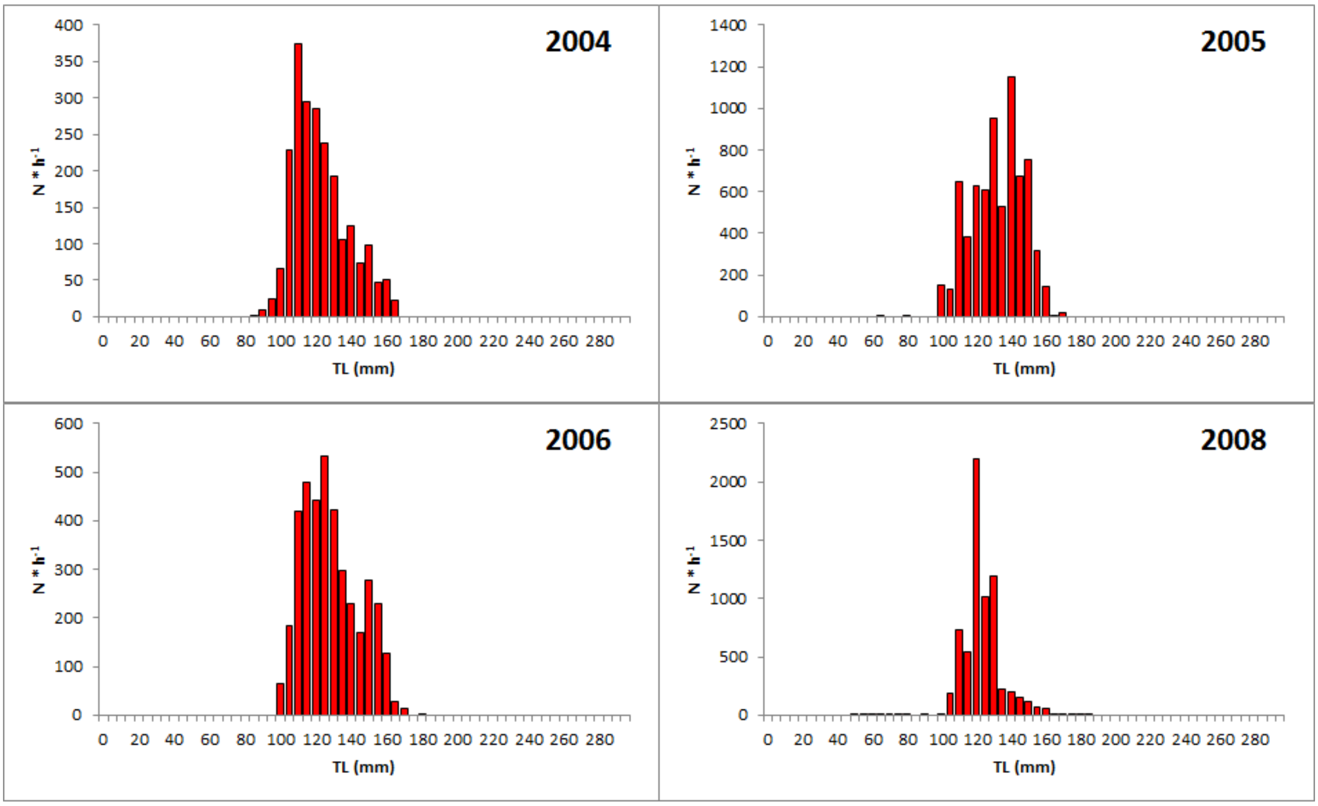



**Fig. 1.5.3.4. Stratified abundance indices by size of picarel in GSA 20, 2004-2008.**

### 1.5.4 *Assessment of historic stock parameters*

#### 1.5.4.1 Method 1: Stock Production Model

***Justification***

A production model has been employed in order to estimate the fishing mortality and the biomass at sea and the relative reference points in term of $F_{MSY}$ and $B_{MSY}$, using the catch and effort data estimated in section 1 of this report and by Moutopuolus and Stergiou (2012) and FAO-FISHSTAT GFCM database.

***Input parameters***

A non-equilibrium dynamic biomass model incorporating covariates [ASPIC 5.10.1] (Prager 2005) was applied to catch and effort (HP x Days) data from the GSA 20, of the four fishing fleet exploiting picarel. Three model shapes, namely: Logistic, Fox and the Generalized Estimate Exponent were used.

In addition to data on catch and effort, ASPIC requires starting guesses and ranges for the parameters to be estimated by the model: carring capacity (K), maximum sustainable yield (MSY), the ratio of the biomass at the beginning of the first year to the carrying capacity (B1/K) and catchability (q) (Table 1.5.4.1).

**Table 1.5.4.1. ASPIC input parameters of the FIT mode for GSA 20.**

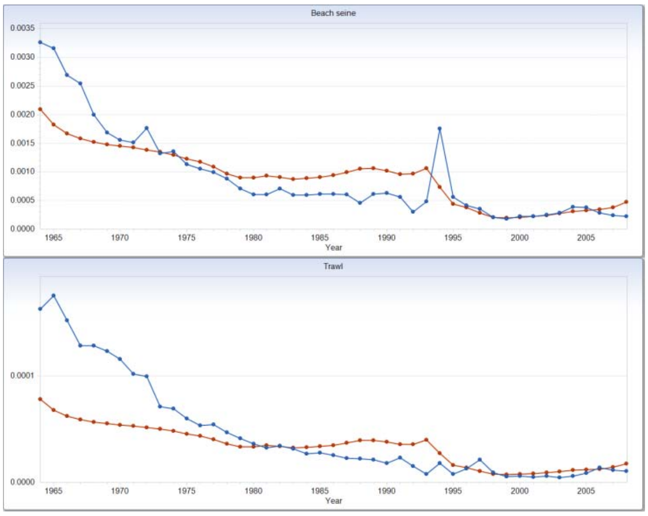
| B1/K | MSY | Range of MSY | K | Range of K | Fishing fleet | q (mean (CPUE) / 2*max(Y)) |
|---|---|---|---|---|---|---|
| 0.5 | 1035 | 500 - 5000 | 21287 | 10000 - 30000 | Beach seine | 5.37884E-07 |
| | | | | | Bottom Trawl | 1.57931E-07 |
| | | | | | Purse seine | 4.10322E-07 |
| | | | | | Small scale | 2.15107E-08 |

After fitting the values for the above parameters, the FIT mode is run. At this point ASPIC computes estimates of parameters, including time trajectories of fishing intensity and stock biomass. The results of the fit were used to compute bias-corrected approximate confidence limits (80% CL) through bootstrap analysis. The model fittings are under the assumption that yield in each year is known more precisely than fishing effort or relative abundance from MEDITS survey, which has been discarded from the model because did not provide a better fit. In other words, all model fittings were conditioned on yield, rather than on effort or relative abundance (Prager 2005).

If there is normal convergence, the point estimates of the FIT mode were loaded in the BOT mode for bootstrapping. In this mode the programme computes bootstrap confidence intervals on estimated quantities. This approach resamples the residuals from the optimum fit to generate new bootstrap samples of the observed time series. The residuals between the observed and predicted catch rates (CPUE), are used for bootstrap analysis. Bootstrap data sets are constructed by combining predicted CPUE with a randomly chosen residual to compute a pseudo-CPUE value. The model is then refit, using the pseudo-CPUE, which is assumed to relate back to stock biomass via the catchability coefficient (CPUE = $qBt$). The process is repeated at least 1000 times (bootstrap trials) for each different fit. At each trial the objective function used is the sum of squared errors (Haddon 2001, Prager 2005).

***Results***

Initial runs in the ASPIC FIT mode for all the three models gave normal convergence. The observed CPUE and predicted CPUE indexes are shown in Figure 1.5.4.1-2 for the logistic, Fox and generalized estimate exponent model. A clear decreasing trend in CPUEs is observed for all the runs and for all the fleets.



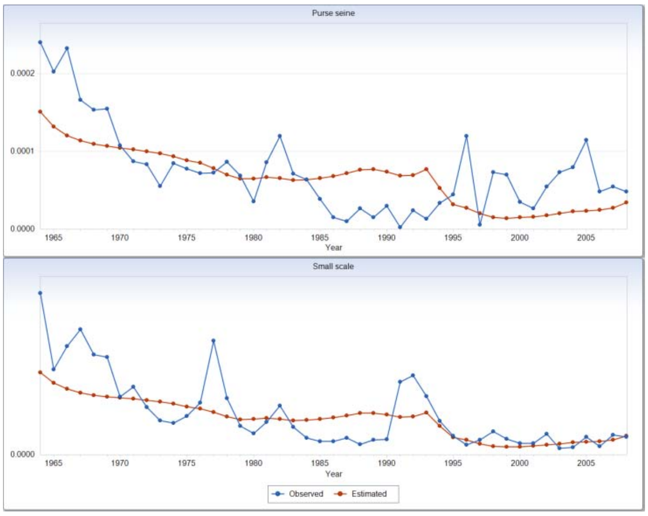



**Fig.1.5.4.1. Observed and predicted values of CPUE of picarel in GSA 20 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1964-2008.**

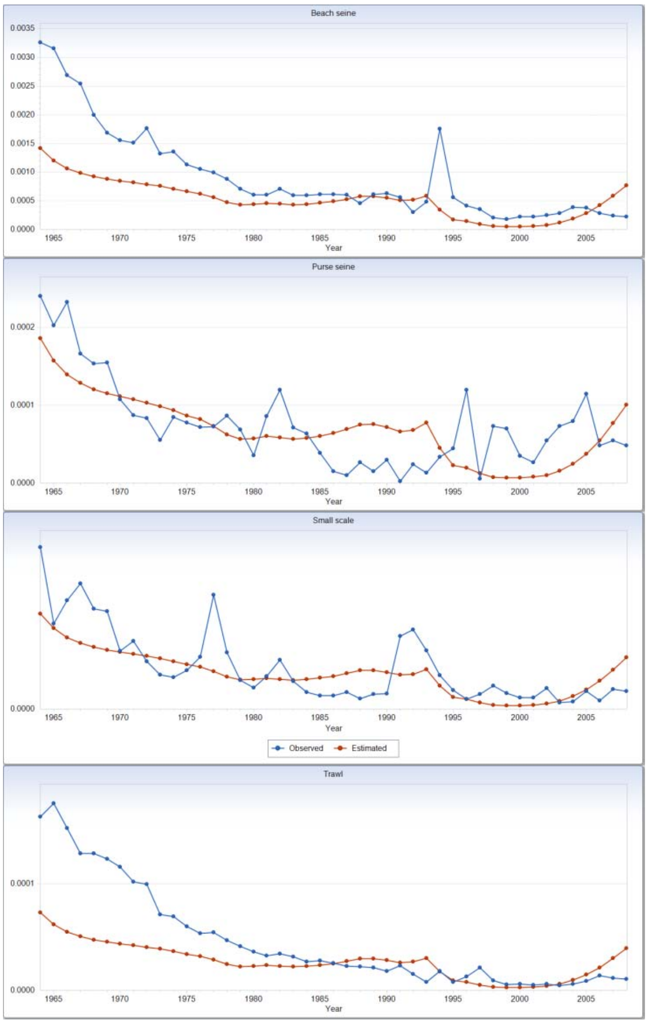



**Figure 1.5.4.2. Observed and predicted values of CPUE of picarel in GSA 20 using the dynamic non-equilibrium Fox model in ASPIC for the period 1964-2008.**

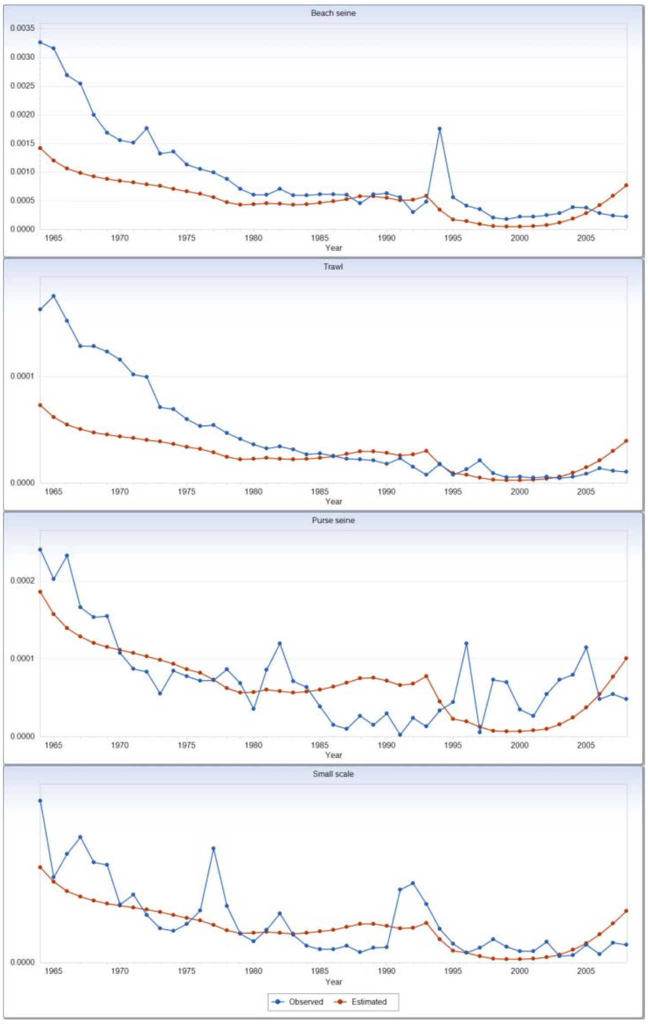



**Fig.1.5.4.3. Observed and predicted values of CPUE of picarel in GSA 20 using the dynamic non-equilibrium Generalized Estimate Exponent model in ASPIC for the period 1964-2008.**

In the logistic model the estimated biomass and fishing mortality fluctuated respectively from 170,000 to 6,000 t and from 0.04 to 0.78 (Figure 1.5.4.4). The biomass showed a general decreasing trend from 1964 to 2008, while the F reached higher values in 1994-2005 than during previous period. The estimated surplus production shows lower values for the last decade in comparison with the period 1970-1994 (Figure 1.5.4.5).

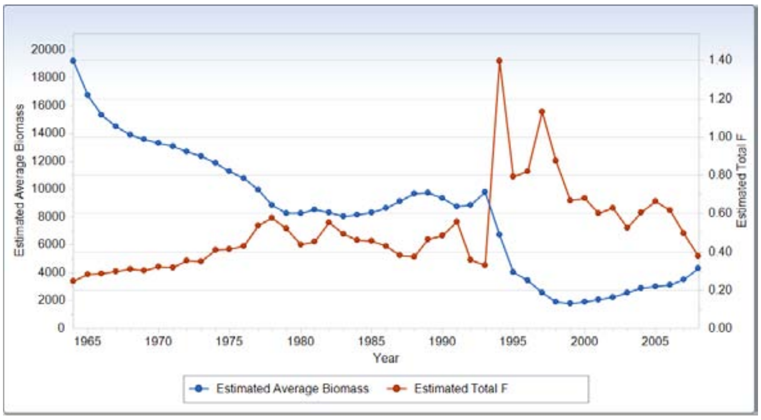



**Fig.1.5.4.4. Estimated average biomass and fishing mortality of picarel in GSA 20 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1964-2008.**

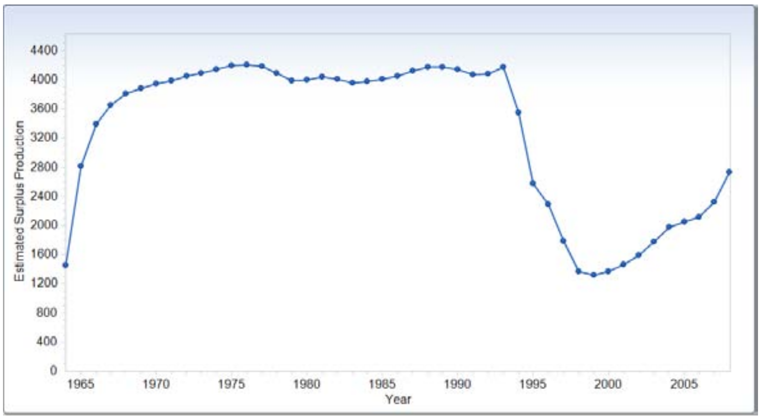



**Fig.1.5.4.5. Estimated surplus production of picarel in GSA 20 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1964-2008.**

In the Fox model the estimated biomass and fishing mortality fluctuated respectively from 19,000 to 500 t and from 0.40 to 2.2 (Figure 1.5.4.6). The biomass showed a general decreasing trend from 1964 to 2000 followed by an increase in the next period. The F reached highest value in 1997. The estimated surplus production shows a clear drop in 1993, followed by general increase from 1999 to 2008 (Figure 1.5.4.7).

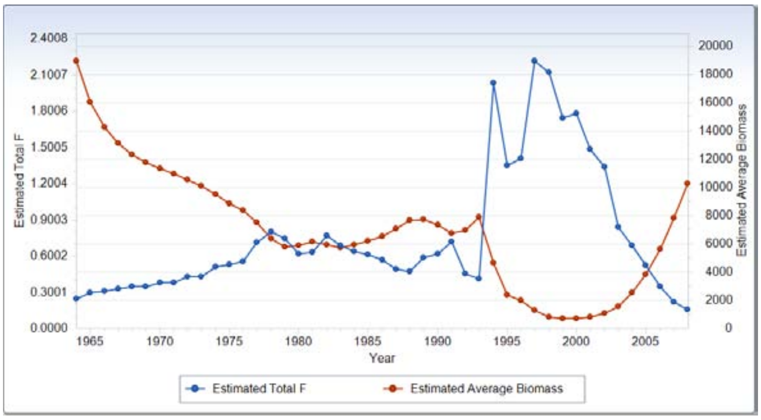



**Fig.1.5.4.6. Estimated average biomass and fishing mortality of picarel in GSA 20 using the dynamic non-equilibrium Fox model in ASPIC for the period 1964-2008.**

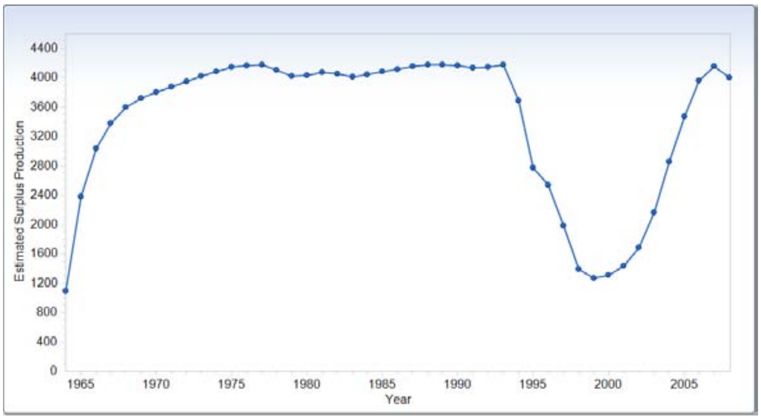



**Fig.1.5.4.7. Estimated surplus production of picarel in GSA 20 using the dynamic non-equilibrium Fox model in ASPIC for the period 1964-2008.**

In the generalized estimate exponent model biomass and fishing mortality fluctuated respectively from 16,000 to 2,000 t and from 0.30 to 1.39 (Figure 1.5.4.8). The biomass showed a decreasing trend from 1964 to 1980, followed by a stable period until 1994, when a clear drop has been estimated. The estimated surplus production shows a clear drop in level for the last decade (Figure 1.5.4.9).

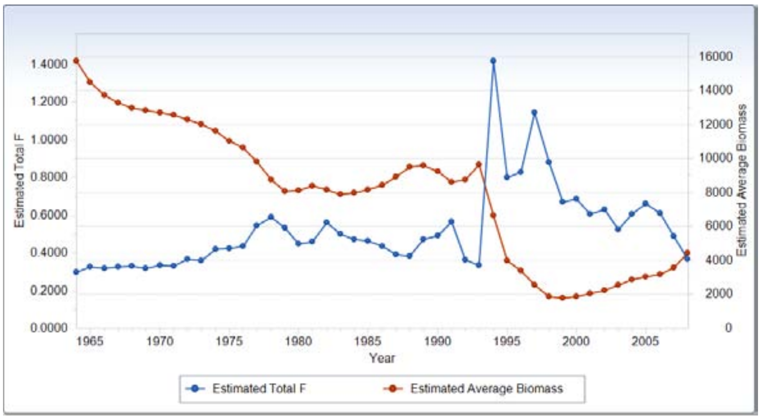



**Fig.1.5.4.8. Estimated average biomass and fishing mortality of picarel in GSA 20 using the dynamic non-equilibrium Generalized Estimate Exponent model in ASPIC for the period 1964-2008.**

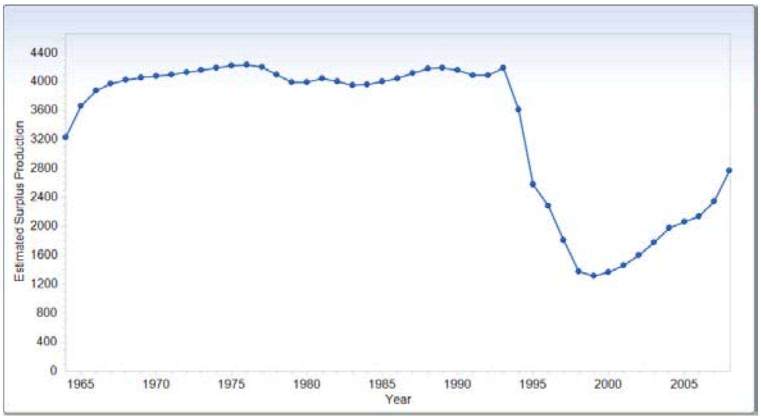



**Fig.1.5.4.9. Estimated surplus production of picarel in GSA 20 using the dynamic non-equilibrium Generalized Estimate Exponent model in ASPIC for the period 1964-2008.**

The goodness of fit of each model is presented in Table 1.5.4.1. The three models presented a general good fit, with the Fox model showing a better fit also in terms of contrast and nearness. The Fox model results have been considered as reference points in Table 1.5.1.5.

**Table 1.5.4.1. Goodness of fit results for the three models in ASPIC.**

| | Loss component number and title | Weighted SSE | N | Weighted MSE | Current weight | Inv. var. weight | R-squared in CPUE |
|---|---|---|---|---|---|---|---|
| Logistic model | Loss(-1) SSE in yield | 0.000E+00 | | | | | |
| | Loss(0) Penalty for B1 > K | 0.000E+00 | 1 | N/A | 0.000E+00 | N/A | |
| | Loss(1) Beach seine | 7.783E+00 | 45 | 1.810E-01 | 1.000E+00 | 1.823E+00 | 0.672 |
| | Loss(2) Trawl | 1.467E+01 | 45 | 3.411E-01 | 1.000E+00 | 9.672E-01 | 0.455 |
| | Loss(3) Purse seine | 4.622E+01 | 45 | 1.075E+00 | 1.000E+00 | 3.070E-01 | 0.297 |
| | Loss(4) Small scale | 1.571E+01 | 45 | 3.654E-01 | 1.000E+00 | 9.029E-01 | 0.497 |
| | TOTAL OBJECTIVE FUNCTION, MSE, RMSE: | 8.43822635E+01 | | 4.850E-01 | 6.964E-01 | | |
| | Estimated contrast index (ideal = 1.0): | 0.9065 | | C* = (Bmax-Bmin)/K | | | |
| | Estimated nearness index (ideal = 1.0): | 1.0000 | | N* = 1 - \|min(B-Bmsy)\|/K | | | |
| Fox model | Loss(-1) SSE in yield | 0.000E+00 | | | | | |
| | Loss(0) Penalty for B1 > K | 0.000E+00 | 1 | N/A | 0.000E+00 | N/A | |
| | Loss(1) Beach seine | 2.756E+01 | 45 | 6.409E-01 | 1.000E+00 | 1.043E+00 | 0.259 |
| | Loss(2) Trawl | 2.259E+01 | 45 | 5.254E-01 | 1.000E+00 | 1.273E+00 | 0.314 |
| | Loss(3) Purse seine | 5.413E+01 | 45 | 1.259E+00 | 1.000E+00 | 5.311E-01 | 0.375 |
| | Loss(4) Small scale | 2.494E+01 | 45 | 5.799E-01 | 1.000E+00 | 1.153E+00 | 0.506 |
| | TOTAL OBJECTIVE FUNCTION, MSE, RMSE: | 1.29217580E+02 | | 7.426E-01 | 8.618E-01 | | |
| | Estimated contrast index (ideal = 1.0): | 0.9542 | | C* = (Bmax-Bmin)/K | | | |
| | Estimated nearness index (ideal = 1.0): | 1.0000 | | N* = 1 - \|min(B-Bmsy)\|/K | | | |

| Generalized model | Estimate | Exponent | |
|---|---|---|---|

```
                                            Weighted            Weighted    Current    Inv. var.   R-squared
Loss component number and title                  SSE      N          MSE     weight       weight     in CPUE

Loss(-1)  SSE in yield                     0.000E+00
Loss(0)   Penalty for B1 > K               0.000E+00      1          N/A  0.000E+00          N/A
Loss(1)   Beach seine                      7.951E+00     45    1.849E-01  1.000E+00    1.852E+00       0.537
Loss(2)   Trawl                            1.591E+01     45    3.700E-01  1.000E+00    9.254E-01       0.371
Loss(3)   Purse seine                      4.639E+01     45    1.079E+00  1.000E+00    3.174E-01       0.219
Loss(4)   Small scale                      1.626E+01     45    3.782E-01  1.000E+00    9.053E-01       0.433
.............................................................................................
TOTAL OBJECTIVE FUNCTION, MSE, RMSE:  8.65187249E+01         5.001E-01  7.072E-01
Estimated contrast index (ideal = 1.0):       0.6954         C* = (Bmax-Bmin)/K
Estimated nearness index (ideal = 1.0):       1.0000         N* = 1 - |min(B-Bmsy)|/K
```

The estimates of MSY, $B_{MSY}$, $F_{MSY}$, $f_{MSY}$ (effort related MSY) for each fleet are shown in Table 1.5.4.2. The estimates of MSY and $F_{MSY}$ ranges after bootstrapping using approximate 80% upper and lower confidence limits are shown in Table 1.5.4.3.

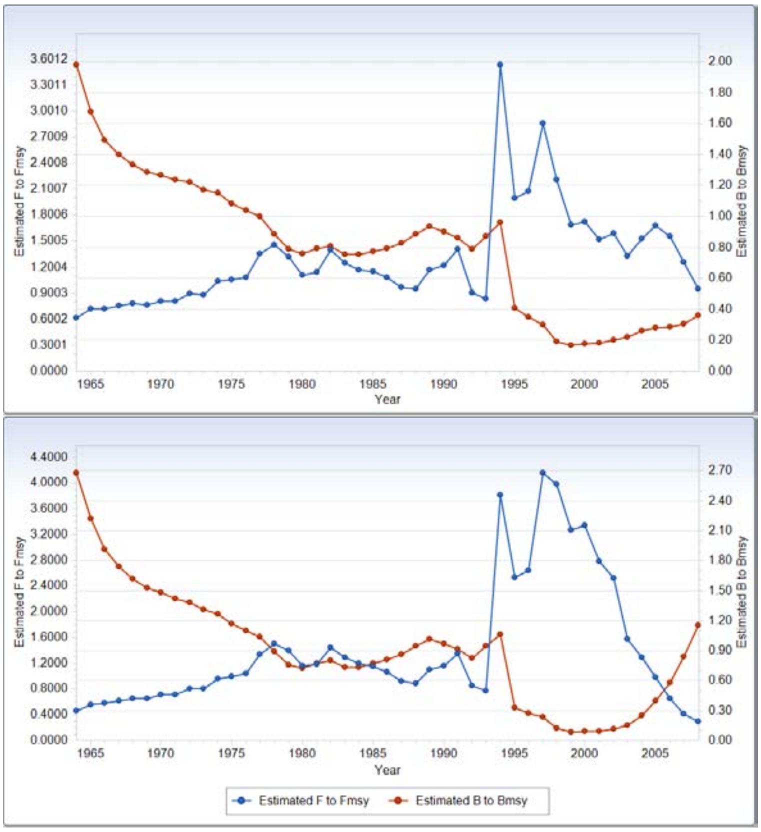
**Table 1.5.4.2. Estimated parameters of picarel in GSA 22 & 23.**

| Model | MSY (tons) | $B_{MSY}$ (tons) | $F_{MSY}$ | $f_{MSY}$ Beach seine | $f_{MSY}$ Trawl | $f_{MSY}$ Purse seine | $f_{MSY}$ Small scale |
|---|---|---|---|---|---|---|---|
| **Logistic** | 4208 | 10640 | 0.39 | 3.624E+06 | 9.719E+07 | 5.028E+07 | 2.296E+08 |
| **Fox** | 4177 | 7831 | 0.53 | 7.115E+06 | 1.382E+08 | 5.441E+07 | 2.643E+08 |
| **GEE** | 4234 | 10840 | 0.40 | 3.995E+06 | 9.820E+07 | 4.938E+07 | 2.256E+08 |

**Table 1.5.4.3. Estimates of MSY and $F_{MSY}$ from bootstrapped analysis in ASPIC with confidence limits.**

| Model | MSY | | | $F_{MSY}$ | | |
|---|---|---|---|---|---|---|
| | 80% lower | | 80% higher | 80% lower | | 80% higher |
| **Logistic** | 4066 | 4208 | 4305 | 0.3955 | 0.3958 | 0.3961 |
| **Fox** | 4152 | 4177 | 4207 | 0.5302 | 0.5315 | 0.5372 |
| **GEE** | 4221 | 4234 | 4334 | 0.3562 | 0.4001 | 0.4514 |

The relative biomass ($B/B_{MSY}$) and fishing mortality ($F/F_{MSY}$) are showed in figure 1.5.4.10 for the three models.



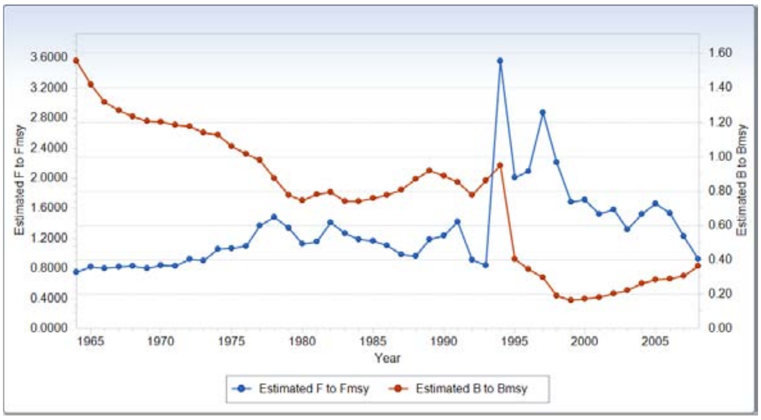



**Figure 1.5.4.10. Historic trend in estimated fishing mortality as F/F$_{MSY}$ ratio and biomass as B/B$_{MSY}$ ratio from Logistic (upper grapf), Fox (middle graph) and Generalized Estimate Exponent (lower graphs) models.**

The results of the production models suggest that picarel in the GSA 20 is exploited sustainably, considering that the current F is below the F$_{MSY}$ in each of the three models run (F/F$_{MSY}$ = 1.15 from the Fox model). The biomass at sea, after the end of the 90s, seems to recover, especially for the Fox model, which estimates a current biomass at sea 20% higher than the B$_{MSY}$ (B/B$_{MSY}$ = 1.15 from the Fox model). Differently the other two models estimate a current biomass that is only 40% of the B$_{MSY}$.

### 1.5.4.2 Method 2: SURBA

***Justification***

The relatively long time series of data available from the MEDITS surveys provided the most useful data sets for analysis. The survey-based stock assessment approach SURBA (Needle, 2003) was used on MEDITS (1994-2009) data for *S. smaris* in GSAs 20. Length was converted to ages based on the growth equation presented in Tab. 1.1.4.1.2.1 for both sexes (Tsangridis, and Filippousis, 1991). Age groups 0 to 6 were identified. However, age group 0 was considered largely undersampled and ages 5 to 6 were merged as a plus group. Thus ages 1 to 5+ were used for analysis. Mean weight at age was a weighted mean based on the length frequency distribution of each age class. Average values were used for the years with missing info. Natural mortality was estimated as a vector for each age group based on ProdBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. F$_{ref}$ was set for ages 1 to 4. Similar to the situation in GSA 22&23, the entire data series (1994-2008) seems to split into 2 separate groups: one prior to 1999 presenting a very small number of catches and one after 1999 that looks more consistent with a high number of catches in all age classes. This is likely to be related to the unsuitability of the MEDITS survey for coastal, shallow waters species like picarel presenting low catchability values. The series for the period 1999-2008 was chosen for analysis. In addition a catchability pattern was defined assuming catchability q to 0.1 (highly undersampled), 0.75, and 0.8 for ages 1, 2 and 3 and 1 for age 4 and 5+.

***Input parameters***

**Table 1.5.4.3. Number at age of *Spicara smaris* in GSA 20.**

| **Survey indexes** | Age 1 | Age 2 | Age 3 | Age 4 | Age 5+ |
|---|---|---|---|---|---|

| (n/h) | | | | | |
|---|---|---|---|---|---|
| 1999 | 0.711837 | 1.498776 | 0.284082 | 0.429388 | 0.218776 |
| 2000 | 4.256693 | 1.150394 | 0.818898 | 0.359055 | 0.218898 |
| 2001 | 1.864802 | 3.463869 | 0.884227 | 1.163947 | 1.243201 |
| 2002 | -99 | -99 | -99 | -99 | -99 |
| 2003 | 1.628464 | 0.919101 | 0.464419 | 0.281648 | 0.164794 |
| 2004 | 1.140891 | 0.817004 | 0.459109 | 0.248583 | 0.120648 |
| 2005 | 1.800475 | 3.377672 | 3.692003 | 1.714964 | 0.25574 |
| 2006 | 1.637097 | 2.16129 | 1.064516 | 0.819355 | 0.251613 |
| 2007 | -99 | -99 | -99 | -99 | -99 |
| 2008 | 1.205033 | 4.054774 | 0.672095 | 0.218357 | 0.088823 |

Not available data due to the lack of survey are indicated as -99.

**Table 1.5.4.4. Weight at age in the stock (in kg) of *Spicara smaris* in GSA 20 for 1999-2008.**

| | Age 1 | Age 2 | Age 3 | Age 4 | Mean Age 5+ |
|---|---|---|---|---|---|
| 1999 | 0.0188 | 0.0323 | 0.0405 | 0.0485 | 0.0534 |
| 2000 | 0.0187 | 0.0307 | 0.0405 | 0.0546 | 0.0534 |
| 2001 | 0.0129 | 0.0194 | 0.0319 | 0.0405 | 0.0479 |
| 2002 | 0.0162 | 0.0256 | 0.0356 | 0.0458 | 0.0531 |
| 2003 | 0.0124 | 0.0191 | 0.0311 | 0.0461 | 0.0534 |
| 2004 | 0.0184 | 0.0307 | 0.0405 | 0.0461 | 0.0534 |
| 2005 | 0.0163 | 0.0248 | 0.0347 | 0.0479 | 0.0534 |
| 2006 | 0.0191 | 0.0314 | 0.0405 | 0.0481 | 0.0561 |
| 2007 | 0.0162 | 0.0256 | 0.0356 | 0.0458 | 0.0531 |
| 2008 | 0.0137 | 0.0194 | 0.0303 | 0.0405 | 0.0526 |

Growth parameters (Tsangridis, and Filippousis, 1991)

| $L_\infty$ | K | $t_0$ |
|---|---|---|
| 196 cm | 0.23 $y^{-1}$ | -1.97 y |

| Length-weight relationships | |
|---|---|
| a | B |
| 0.00002 | 2.8439 |

| Maturity at Age (Based on GSA 25 estimates) | | | | |
|---|---|---|---|---|
| Age 1 | Age 2 | Age 3 | Age 4 | Mean Age 5-6 |
| 0.85 | 0.9 | 0.85 | 0.97 | 0.96 |

| Natural mortality (M) | | | | |
|---|---|---|---|---|
| Age 1 | Age 2 | Age 3 | Age 4 | Mean Age 5-6 |
| 0.518431 | 0.44933 | 0.42127 | 0.406051 | 0.390538 |

***Results***

The residual plots of log catchabilities show no apparent trend or pattern. The highest residuals were observed in for age 5+.

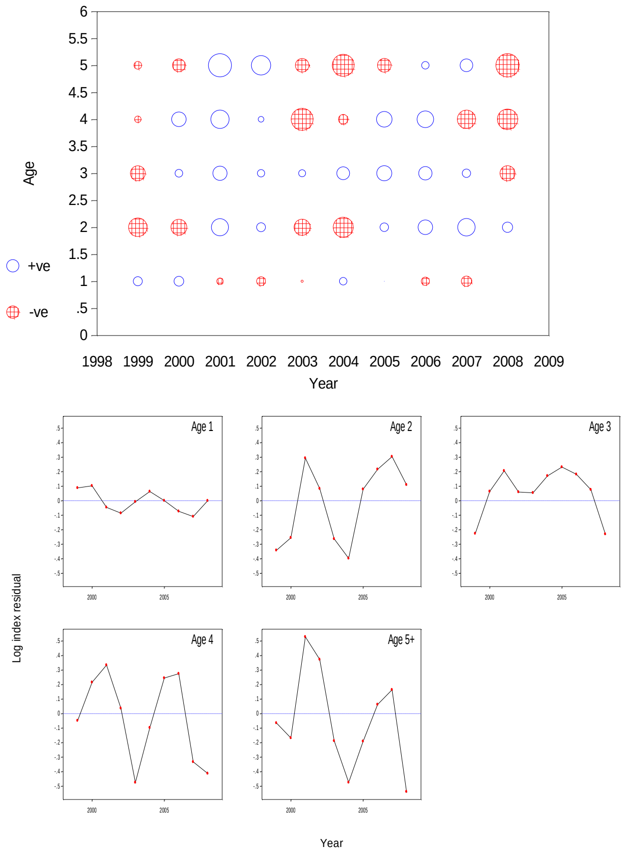



**Fig. 1.5.4.11. Residual plot of log index catchabilities per age and year of *S. smaris* SURBA model in GSA 20 (1999-2008).**

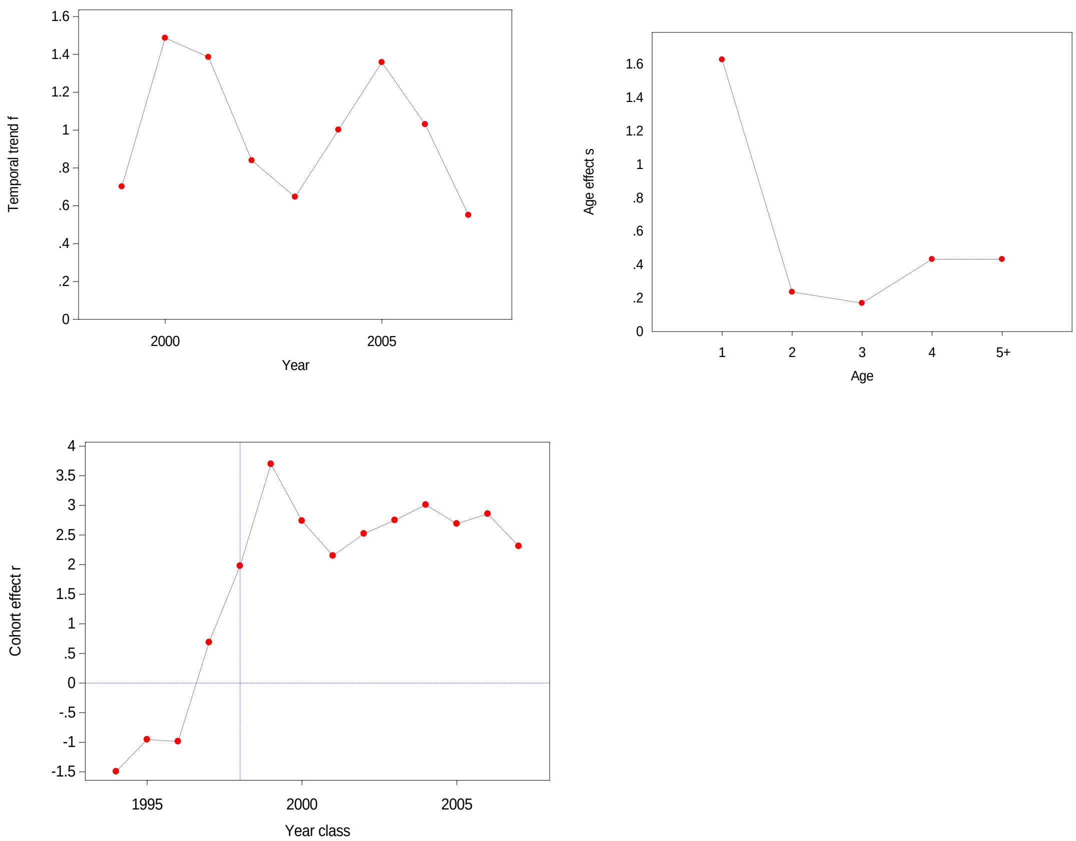


**Fig. 1.5.4.12. MEDITS survey. Fitted year, age and cohort effects estimated for *S. smaris* by SURBA model in GSA 20 (1999-2008).**

Fitted year effect, that is the model proxy for the combination of fishing effort and mean natural mortality in the underlying population, is highly variable indicating no consistent pattern. Fitted age effect shows a decrease from age 1 to age 3 rising to a higher level for ages 4 and 5+. However this might be driven by the catchability selection pattern. Fitted cohort effect shows an increasing trend (Figure 1.5.4.12).

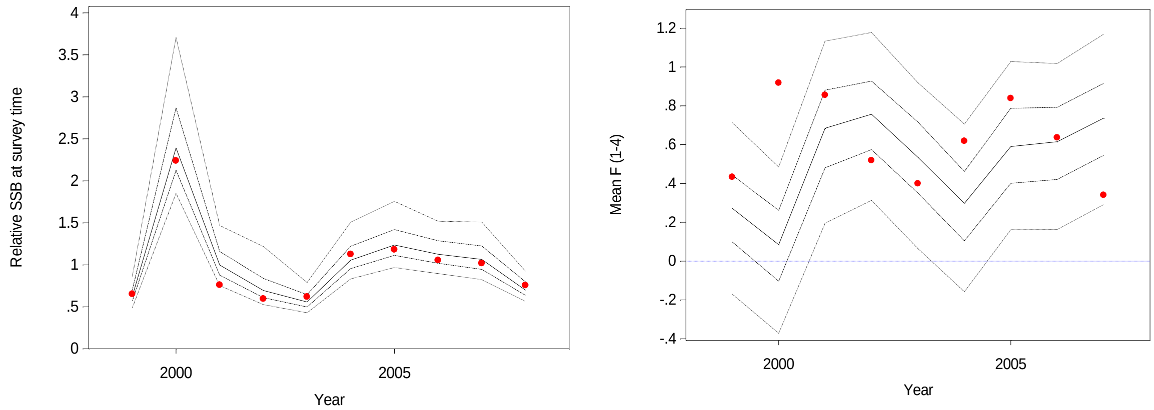
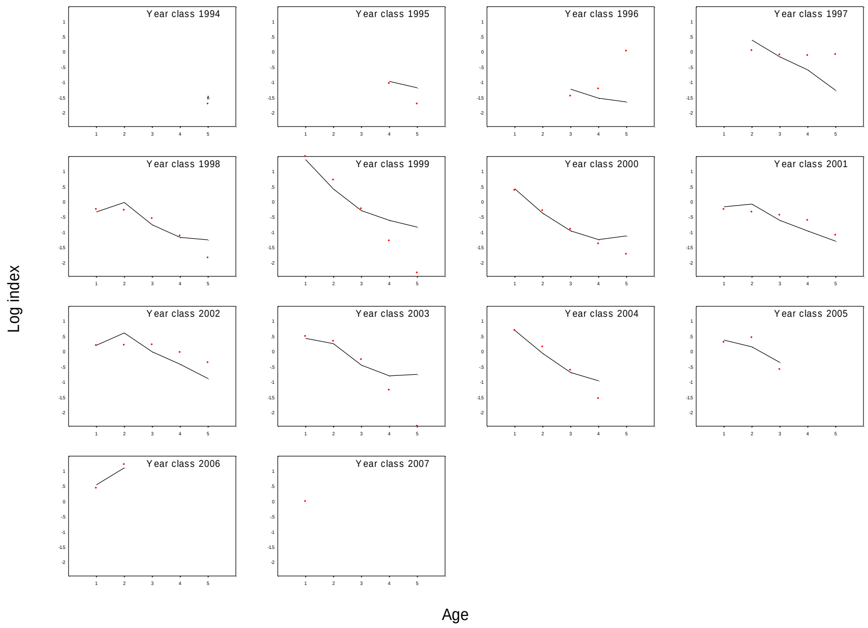



**Fig. 1.5.4.13. MEDITS survey. Estimated trend in F and relative SSB using SURBA. 50$^{th}$ percentile of bootstrapped runs (solid line) and 5% and 95% percentiles of bootsrapped runs (dashed lines).**

The model estimates a rather irregular pattern in mean F. An increase in SSB is estimated for 2001 stabilizing in lower levels after (1.5.4.13). Model diagnostics (Fig. 1.5.4.14) show poor model fit.

Retrospective analysis was applied in the SURBA model for the period 1999-2008 with 5 years backward analysis. Retrospective bias was identified in the age effect and the temporal trend (Fig. 1.5.4.15).

The assessment generally cannot be considered reliable since age cohorts present a poor fit, estimated index for F, SSB and recruitment are highly irregular. In addition the analysis is largely driven by the selected catchability pattern.



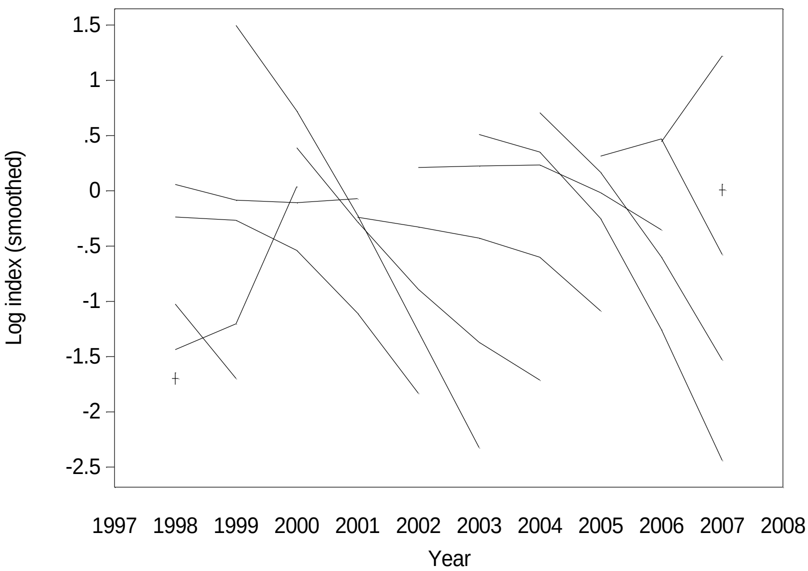




**Fig. 1.5.4.14. Model diagnostics for *S. smaris* SURBA model in the GSA 20 (MEDITS data). Top: Comparison between observed (points) and fitted (lines) survey abundance indices, for each year. Bottom: Log survey abundance indices by cohort. Each line represents the log index abundance of a particular cohort throughout its life.**

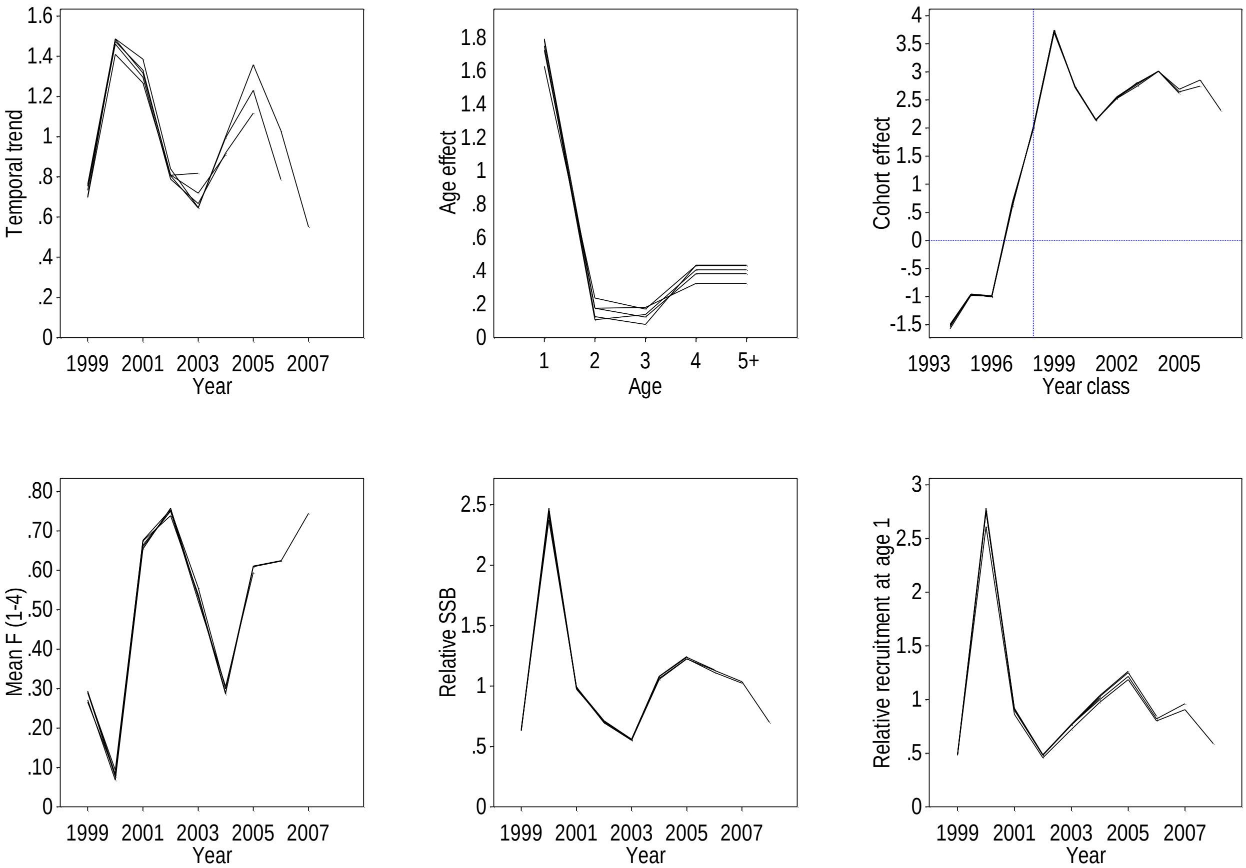



**Fig. 1.5.4.15. Model diagnostics for *S. smaris* SURBA model in the GSA 20 (MEDITS data). Results of retrospective analysis with 5 years period.**

1.5.5 *Long term prediction*

1.5.5.1 Results

In Table 1.5.5.1 are showed the management reference points estimate by ASPIC.

**Table 1.5.5.1 Reference points.**

| | |
|---|---|
| Maximum sustainable yield (MSY; tons) | 4177 |
| Stock biomass giving MSY ($B_{MSY}$; tons) | 7831 |
| Fishing mortality rate at MSY ($F_{MSY}$) | 0.53 |

1.5.6 *Scientific advice*

1.5.6.1 Short term considerations

***State of the spawning stock size***

In the absence of proposed or agreed precautionary reference points is not possible to fully evaluate the status of the spawning stock size in respect to these. In the current stock assessment, SURBA results are not considered reliable.

***State of biomass at sea***

The biomass at sea is recovering after a period of low values comprised between 1995 and 2005. The total biomass at sea in 2008 estimated with the production model using the Fox approach is 1.15 times of $B_{MSY}$ ($B/B_{MSY} = 1.15$).

***State of recruitment***

Is not possible to provide any scientific advice of the state of the recruitment as SURBA results are not considered reliable.

***State of exploitation***

The results from ASPIC suggests that the stock is exploited sustainably ($F/F_{MSY} = 0.30$). SURBA results, due to the poor fit, are not considered reliable to evaluate the status of the exploitation.

#### 1.5.6.2 Data quality

The data used in the production model are estimates of landings of picarel and effort for GSA 20 provided in Section 1 of this report, by Moutopoulos and Stergiou (2012) and and FAO-FISHSTAT GFCM database. Discard data were not available for this stock, as well as maturity and growth information. MEDITS survey seems to be unsuitable for picarel since the survey design is not adjusted for coastal shallow water species.

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## 1.6 **Stock assessment of picarel in GSA 22 & 23**

### 1.6.1 *Stock identification and biological features*

#### 1.6.1.1 Stock Identification

*Spicar smaris* (picarel) is a very common Mediterranean demersal fish and is important for the Mediterranean and the Greek fishery. It is a sequential protogynous hermaphrodite fish, which displays sexual dimorphism during the reproductive period (Zei, 1941, 1949; Tortonese, 1975; Whitehead et al., 1986). The lack of information on the biology of the species (i.e. distribution, dispersal, tagging experiments, etc.) may be due to the systematic confusion of the family Centracanthidae, which persisted until at least 1970 (Pollard and Pichot, 1971). The eggs of the picarel are demersal (Tortonese, 1975). The dispersal of the species on the Cretan Continental shelf is characterised by seasonal fluctuations in the bathymetric distribution and the relative abundance of different length and sex groups of the species, while the larvae remain on the reproductive and nursery grounds (Vidalis, 1994). From the above information we may conclude that the dispersal of the species seems to be correlated with the dispersal of the adults. A study examinig the homogeneity of the population of the picarel in the Aegean Sea, in order to recognise the existence of different stocks, analysing the variability of morphometric and meristic characters in fishes caught in the basin, evidenced very low or null variability (Vidalis et al., 1997).

#### 1.6.1.2 Growth

Several studies have been performed on age determination of picarel in different Mediterranean areas based on otolith and scale readings or on length frequency distribution (Zei, 1951; Matta, 1958; Passelaigue, 1974; Salekhova, 1979; Papaconstantin et al., 1985; Tsangridis and Filippousis, 1988; Tsangridis and Filippousis, 1991; Tsangridis and Filippousis, 1992), but very little has been done to validate aging.

Furthermore, some of the findings of the mentioned studies seem to be contradictory, concerning the mean length at age, and the growth of the picarel. Vidalis and Tsimenid (1996) validated the age determination of otolith reading and estimated the growth parameters of picarel caught off the coasts of Crete (Table 1.6.1.1). Length-weight relationship was calculated for male, female and the sexes combined and are presented in Table 1.6.1.1.

**Table 1.6.1.1. Growth parameters of *S. smaris*.**

| | Sex | $L_{inf}$ | k | $t_0$ | a | b |
|---|---|---|---|---|---|---|
| Vidalis and Tsimenid (1996) | Female | 128.4 | 0.921 | -0.215 | 0.0000056 | 3.17 |
| | Male | 192.3 | 0.154 | -3.522 | 0.0000039 | 3.25 |
| | Sex combined | 137.8 | 0.393 | -0.678 | 0.0000046 | 3.21 |
| Tsangridis, and Filippousis, 1991 | Sex combined | 19.6 | 0.2 | -1.97 | | |

The von Bertalanffy growth parameters of picarel used in the present assessment were the ones estimated by (Tsangridis, and Filippousis, 1991) estimating Linf=19.6 cm, k=0.23, to=-1.97 were utilized in the analyses of GSA 22&23. The estimation of these parameters was based on data from GSA 23.

Parameters of the length-weight relationship, related to combined sex, are: a=0.00001, b = 2.9001 (for length expressed in mm) based on estimates of HCMR landing information.

#### 1.6.1.3 Maturity

The length at maturity has been estimated by Stergiou et al. 2004 as 12.8 cm. The maturity ogive of the stock (sex combined), as provided through the 2010 Official EC Data Call, is presented in Table 1.6.1.2. Data used were collected under the Cyprus National Programme during 2006-2008.

**Tab. 1.6.1.2. Maturity ogive data of *S. smaris* in GSA 22&23.**

| Age | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Prop. Mature | 0.79 | 0.85 | 0.90 | 0.85 | 0.97 | 0.96 |

### 1.6.2 *Fisheries*

#### 1.6.2.1 General description of fisheries

During the years 1970-2008 the mean annual Mediterranean production of the picarel was 13 thousand tonnes. More than 50% of the total annual Mediterranean production was caught in Greek seas (FAO-FishStatj, 2011). Picarel landings of Turkey coming from the aegean sea represent on avarage less than 10% of the entire basin landings (FAO-FishStatj, 2011). The species in the Aegean sea is mainly caught by beach seines and trawlers, while only a small quantity is landed by the artisanal fishery and purse seine (Moutoupolous and Stergiou, 2012).

*Catches*

***Landings***

The landings of *S. smaris* in GSA 22-23 by the main fisheries for the period 1964-2008 are given in Figure 1.6.2.1. The species has been mostly exploited by the beach seine until 1997, with the maximum value observed in 1994. In the followed period the landings are much lower and the amount of landings of beach seine is in the same as the one of the trawl (Moutoupolous and Stergiou, 2012). Since the data series presented by Moutoupolous and Stergiou (2012) ends in 2007, the amount of landing for each fleet in 2008 has been estimated using the total value presented in GFCM-FAO FishstatJ database. Such amount has been allocated in each fleet segment on the base of the proportion observed in 2007.

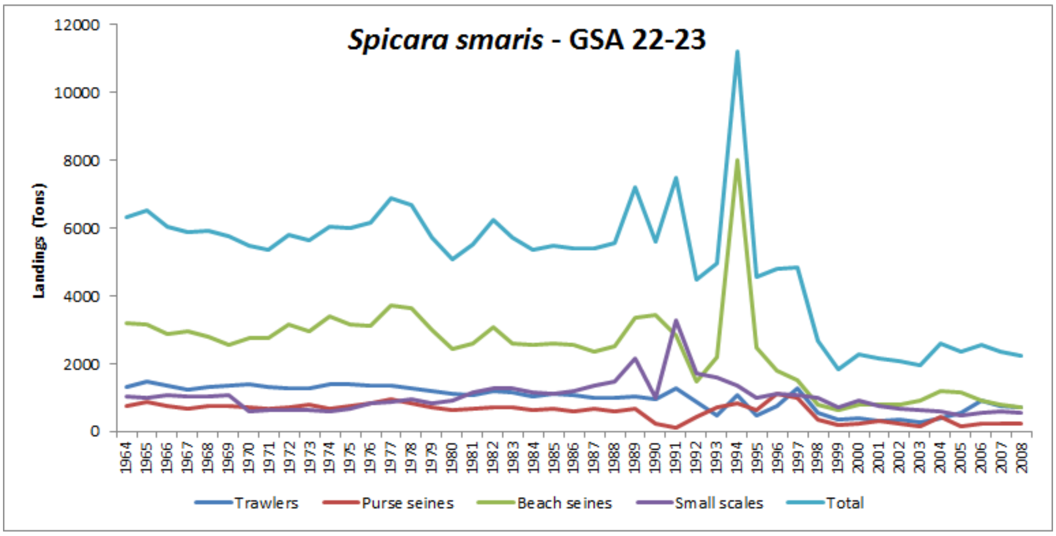



**Fig. 1.6.2.1. Landings of *S. smaris* in GSA 22&23 (only Greece) by fishing gear for the period 1964-2008.**

***Discards***

Estimates of *S. smaris* discards for GSAs 22 & 23 are not available.

***Fishing effort***

Fishing effort data in GSA 22&23 were provided according to the 2009 Official EC Data Call. Table 1.6.2.1 lists the reported effort for bottom trawler (OTB), small scale fishery (GTR and LLS), purse seine (PS) and beach seine (SB) in GSA 22&23.

**Table 1.6.2.1. Effort in GSA 22-23 expressed in (KW*DAYS)/1000, 2003-2008.**

| YEARS | GTR | LLS | OTB | PS | SB |
|---|---|---|---|---|---|
| **2003** | 68846 | 1888 | 15793 | 9389 | 2776 |
| **2004** | 70634 | 4977 | 15875 | 9141 | 2207 |
| **2005** | 70747 | 2716 | 17731 | 9656 | 2194 |
| **2006** | 66781 | 3848 | 16424 | 8993 | 2022 |
| **2008** | 50244 | 7915 | 16013 | 8234 | 1775 |

1.6.3 *Scientific surveys*

1.6.3.1 MEDITS

***Methods***

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 22&23 the following numbers of hauls were reported per depth stratum (Tab. 1.6.3.1).

**Table 1.6.3.1. Number of hauls per year and depth stratum in GSA 22&23.**

| Stratum | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2003 | 2004 | 2005 | 2006 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **010-050** | 10 | 10 | 11 | 10 | 13 | 12 | 12 | 13 | 13 | 13 | 14 | 12 | 13 |
| **050-100** | 17 | 21 | 22 | 28 | 23 | 26 | 22 | 25 | 25 | 23 | 24 | 26 | 26 |
| **100-200** | 19 | 25 | 37 | 36 | 37 | 33 | 37 | 35 | 36 | 43 | 41 | 41 | 40 |
| **200-500** | 28 | 35 | 44 | 50 | 51 | 51 | 50 | 48 | 51 | 52 | 52 | 52 | 52 |
| **500-800** | 18 | 12 | 19 | 21 | 22 | 21 | 20 | 17 | 17 | 16 | 17 | 16 | 17 |
| **TOTAL** | 92 | 103 | 133 | 145 | 146 | 143 | 141 | 138 | 142 | 147 | 148 | 147 | 148 |

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$
$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution and quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

***Geographical distribution patterns***

Figure 1.6.3.1 provides the distribution of sampling hauls of the MEDITS survey in GSA 22&23.

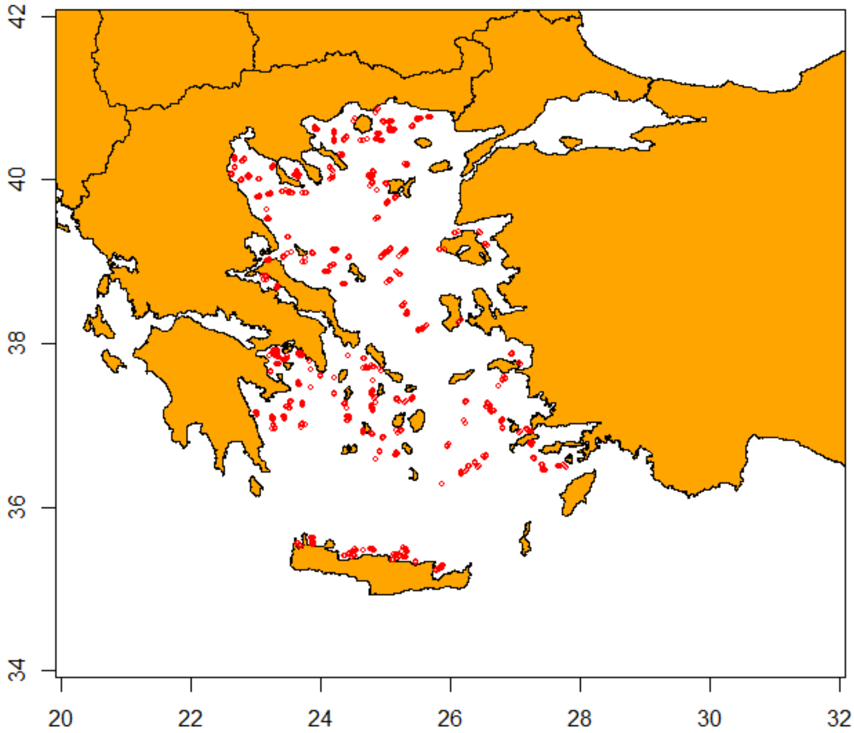



**Fig. 1.6.3.1. Distribution of sampling hauls of the MEDITS survey in GSA 22&23.**

***Trends in abundance and biomass***

Fishery independent information regarding the state of picarel in GSA 22&23 was derived from the international survey MEDITS.

Figure 1.6.3.2 displays the estimated trend in picarel abundance and biomass in GSA 22&23. The estimated abundance and biomass indices reveal general increase both in number and in biomass.

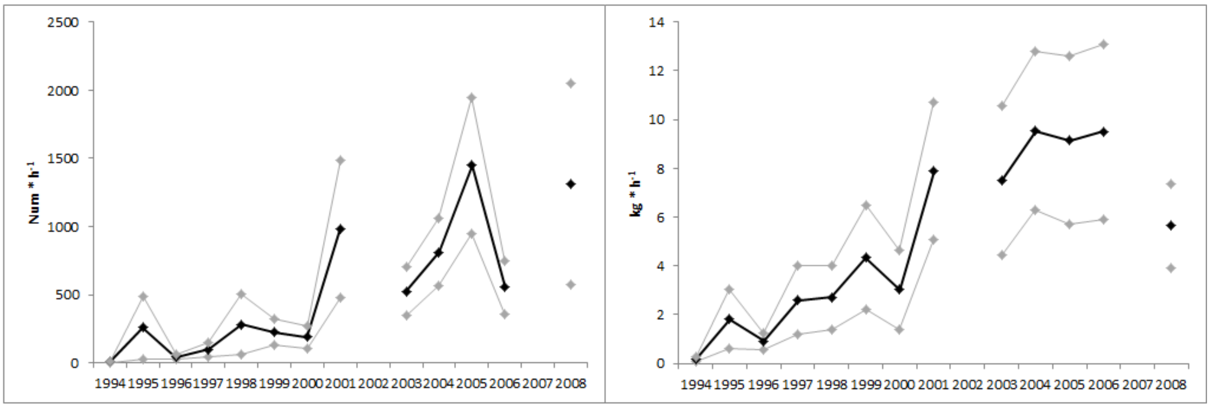



**Fig. 1.6.3.2. Abundance and biomass indices of picarel in GSA 22&23 of picarel in GSA 22&23, Strata 1, 2 and 3.**

***Trends in abundance by length or age***

The following Figure 1.6.3.3-4 displays the stratified abundance indices of GSA 22&23 in 1994-2008.

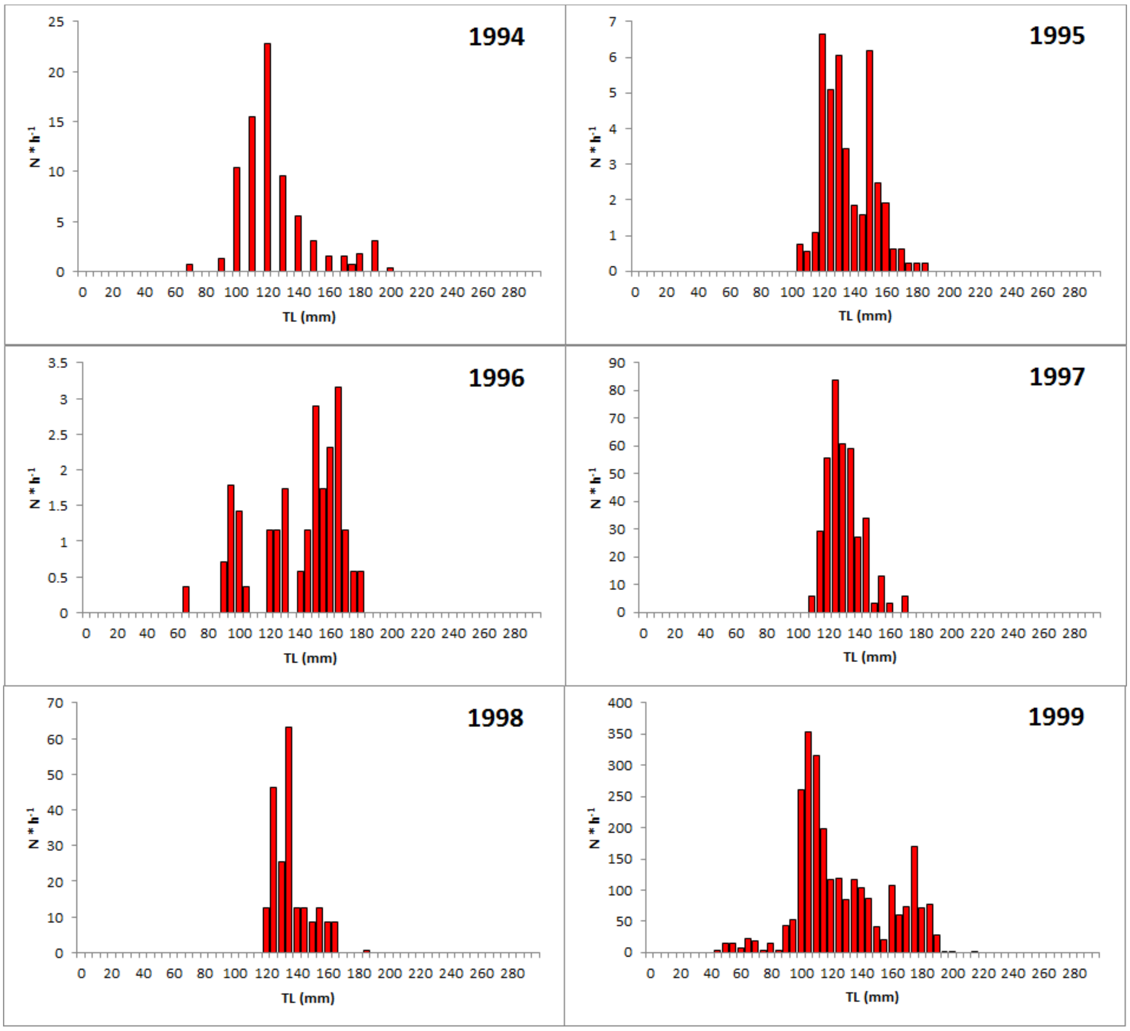



**Fig. 1.6.3.3. Stratified abundance indices by size of picarel in GSA 22&23, 1994-1999.**

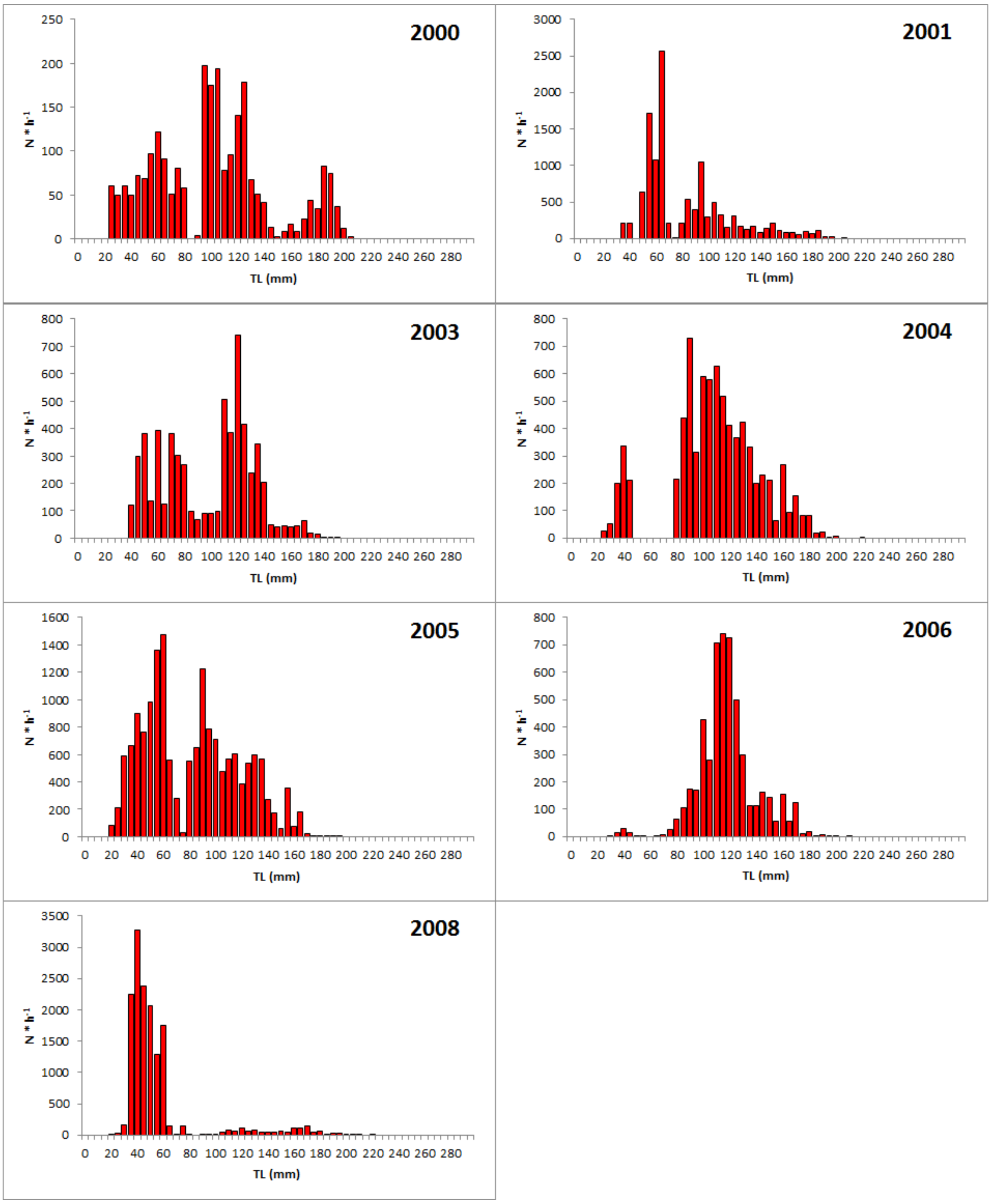



**Fig. 1.6.3.4. Stratified abundance indices by size of picarel in GSA 22&23, 2000-2008.**

## 1.6.4 *Assessment of historic stock parameters*

### 1.6.4.1 Method 1: Stock Production Model

***Justification***

A production model has been employed in order to estimate the fishing mortality and the biomass at sea and the relative reference points in term of $F_{MSY}$ and $B_{MSY}$, using the catch and effort data estimated AS IN Section 1 of this report and by Moutoupolous and Stergiou (2012).

***Input parameters***

A non-equilibrium dynamic biomass model incorporating covariates [ASPIC 5.10.1] (Prager 2005) was applied to catch and effort (HP x Days) data from the GSAs 22 and 23, of the four fishing fleets exploiting picarel. Three model shapes, namely: Logistic, Fox and the Generalized Estimate Exponent were used.

In addition to data on catch and effort, ASPIC requires starting guesses and ranges for the parameters to be estimated by the model: carring capacity (K), maximum sustainable yield (MSY), the ratio of the biomass at the beginning of the first year to the carrying capacity (B1/K) and catchability (*q*) (Table 1.6.4.1).

**Table 1.6.4.1. ASPIC input parameters of the FIT mode for picarel in GSA 22 & 23.**

| B1/K | MSY | Range of MSY | K | Range of K | Fishing fleet | q (mean (CPUE) / 2*max(Y)) |
|---|---|---|---|---|---|---|
| 0.5 | 5.02 E+03 | 5.02 E+02 - 1.0 E+05 | 5.02 E+04 | 5.02 E+03 - 1.00 E+06 | Beach seine | 5.77 E-08 |
| | | | | | Bottom Trawl | 1.55 E-08 |
| | | | | | Purse seine | 4.60 E-08 |
| | | | | | Small scale | 6.79 E-09 |

After fitting the values for the above parameters, the FIT mode is run. At this point ASPIC computes estimates of parameters, including time trajectories of fishing intensity and stock biomass. The results of the fit were used to compute bias-corrected approximate confidence limits (80% CL) through bootstrap analysis. The model fittings are under the assumption that yield in each year is known more precisely than fishing effort or relative abundance from MEDITS survey, which has been discarded from the model because did not provide a better fit. In other words, all model fittings were conditioned on yield, rather than on effort or relative abundance (Prager 2005).

If there is normal convergence, the point estimates of the FIT mode were loaded in the BOT mode for bootstrapping. In this mode the programme computes bootstrap confidence intervals on estimated quantities. This approach resamples the residuals from the optimum fit to generate new bootstrap samples of the observed time series. The residuals between the observed and predicted catch rates (CPUE), are used for bootstrap analysis. Bootstrap data sets are constructed by combining predicted CPUE with a randomly chosen residual to compute a pseudo-CPUE value. The model is then refit, using the pseudo-CPUE, which is assumed to relate back to stock biomass via the catchability coefficient (CPUE = qBt). The process is repeated at least 1000 times (bootstrap trials) for each different fit. At each trial the objective function used is the sum of squared errors (Haddon 2001, Prager 2005).

***Results***

Initial runs in the ASPIC FIT mode for all the three models gave normal convergence. The observed CPUE and predicted CPUE indexes are shown in Figure 1.6.4.1-3, respectively for the logistic, Fox and generalized estimate exponent model. A clear decreasing trend in CPUEs is observed for all the runs.

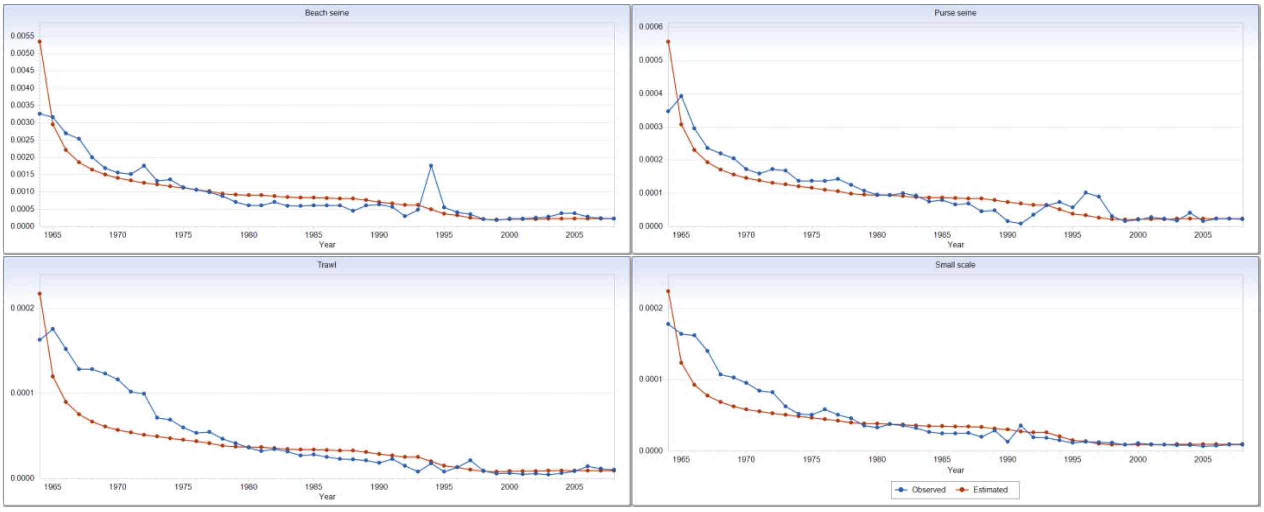



**Fig.1.6.4.1. Observed and predicted values of CPUE of picarel in GSA 22&23 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1964-2008.**

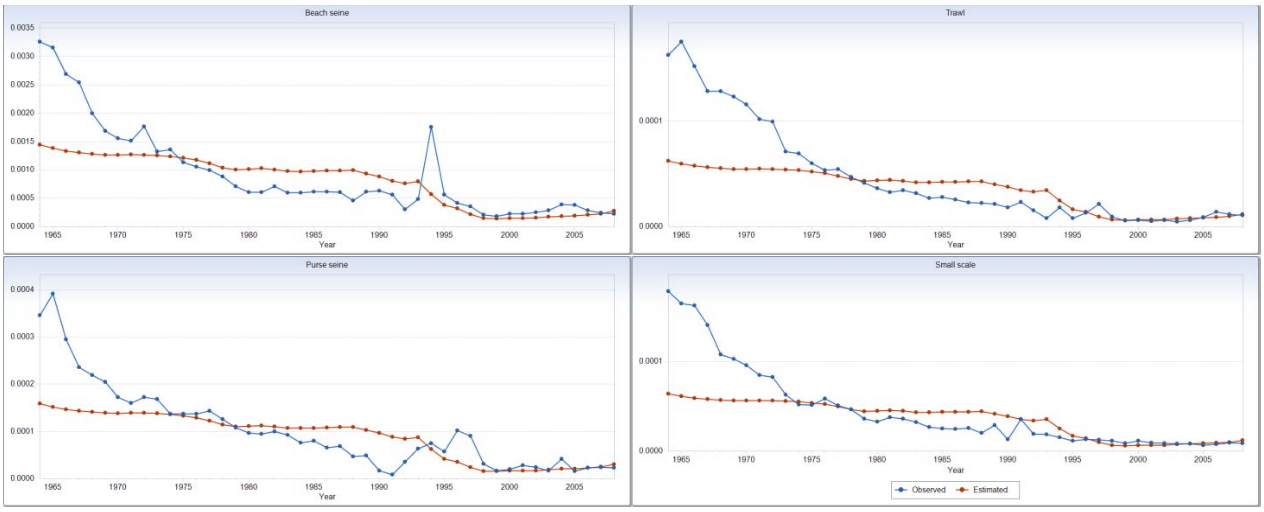



**Fig.1.6.4.2. Observed and predicted values of CPUE of picarel in GSA 22&23 using the dynamic non-equilibrium Fox model in ASPIC for the period 1964-2008.**


**Fig.1.6.4.3. Observed and predicted values of CPUE of picarel in GSA 22&23 using the dynamic non-equilibrium Generalized Estimate Exponent model in ASPIC for the period 1964-2008.**

In the logistic model the estimated biomass and fishing mortality fluctuated respectively from 160,000 to 6,000 t and 0.04 and 0.78 (Figure 1.6.4.4). The biomass was estimated to be lowest since 1969, while the F reached highest values from 1994 to 2008. The estimated surplus production shows a lower level for the last decade (Figure 1.6.4.5).

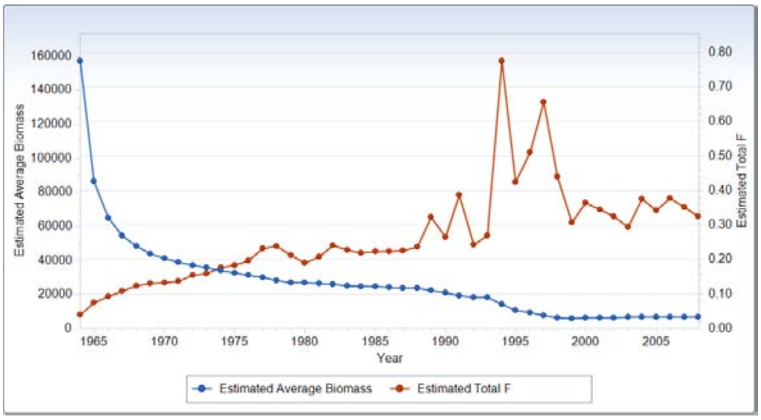



**Fig. 1.6.4.4. Estimated average biomass and fishing mortality of picarel in GSA 22&23 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1964-2008.**

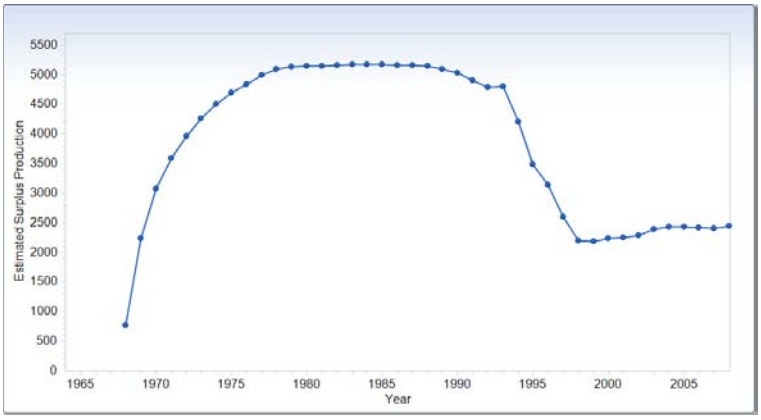



**Fig.1.6.4.5. Estimated surplus production of picarel in GSA 22&23 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1964-2008.**

In the Fox model the estimated biomass and fishing mortality fluctuated respectively from 24,000 to 2,000 t and 0.44 and 1.39 (Figure 1.6.4.6). The biomass showed a decreasing trend from 1964 to 1998 followed by a slight increase in the next period. The F reached higher values from 1994 to 2008. The estimated surplus production shows a clear drop in level for the last decade (Figure 1.6.4.7).

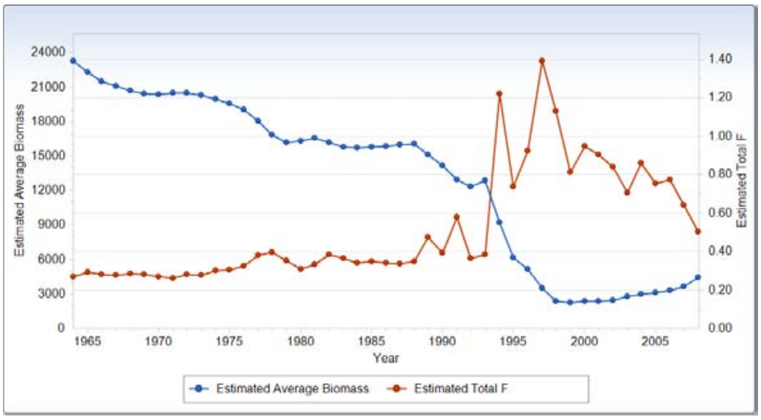



**Fig.1.6.4.6. Estimated average biomass and fishing mortality of picarel in GSA 22&23 using the dynamic non-equilibrium Fox model in ASPIC for the period 1964-2008.**

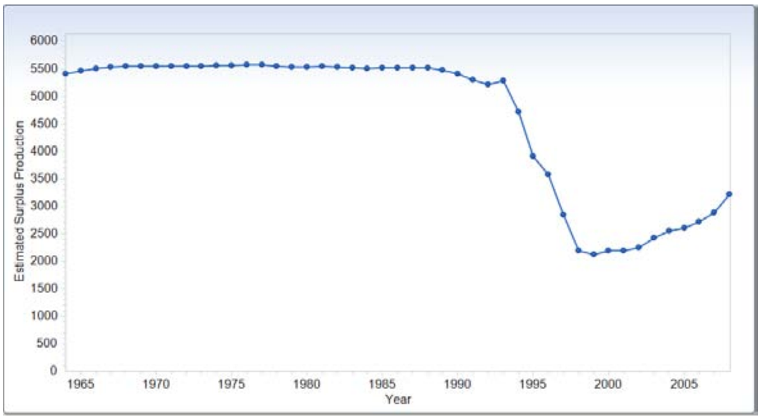



**Fig.1.6.4.7. Estimated surplus production of picarel in GSA 22&23 using the dynamic non-equilibrium Fox model in ASPIC for the period 1964-2008.**

In the generalized estimate exponent model biomass and fishing mortality fluctuated respectively from 18,500 to 3,500 t and 0.30 and 0.92 (Figure 1.6.4.8). The biomass showed a decreasing trend from 1964 to 1993 and a drop in the following period. The F showed higher values from 1994 to 2008. The estimated surplus production shows a clear drop in level for the last decade (Figure 1.6.4.9).

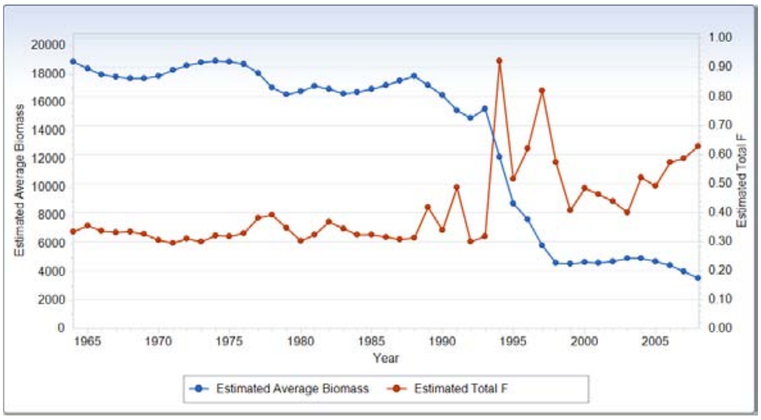



**Fig.1.6.4.8. Estimated average biomass and fishing mortality of picarel in GSA 22&23 using the dynamic non-equilibrium Generalized Estimate Exponent model in ASPIC for the period 1964-2008.**

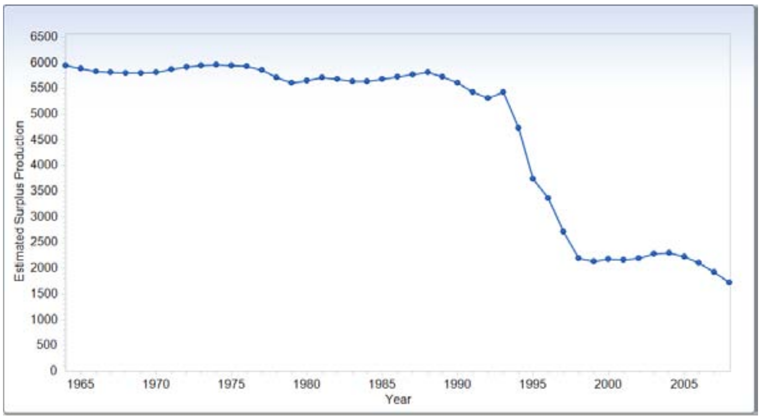



**Fig.1.6.4.9. Estimated surplus production of picarel in GSA 22&23 using the dynamic non-equilibrium Generalized Estimate Exponent model in ASPIC for the period 1964-2008.**

The goodness of fit of each model is presented in Table 1.6.4.2. The three models presented a general good fit, with the Fox model showing a better fit also in terms of contrast and nearness. The Fox model results have been considered as reference points in Table 1.6.4.3.

**Table 1.6.4.2. Goodness of fit results for the three model in ASPIC.**

| | |
|---|---|
| Logistic model | Loss component number and title \| Weighted SSE \| N \| Weighted MSE \| Current weight \| Inv. var. weight \| R-squared in CPUE<br>Loss(-1) SSE in yield 0.000E+00<br>Loss(0) Penalty for B1 > K 0.000E+00 1 N/A 0.000E+00 N/A<br>Loss(1) CPUE from fishery, Yield 5.198E+00 45 1.209E-01 1.000E+00 1.239E+00 0.710<br>Loss(2) Series 2 8.569E+00 45 1.993E-01 1.000E+00 7.519E-01 0.688<br>Loss(3) Series 3 1.271E+01 45 2.956E-01 1.000E+00 5.069E-01 0.737<br>Loss(4) Series 4 4.290E+00 45 9.978E-02 1.000E+00 1.502E+00 0.780<br>TOTAL OBJECTIVE FUNCTION, MSE, RMSE: 3.07686799E+01 1.768E-01 4.205E-01<br>Estimated contrast index (ideal = 1.0): 5.1414 C* = (Bmax-Bmin)/K<br>Estimated nearness index (ideal = 1.0): 1.0000 N* = 1 - \|min(B-Bmsy)\|/K |
| Fox model | Loss component number and title \| Weighted SSE \| N \| Weighted MSE \| Current weight \| Inv. var. weight \| R-squared in CPUE<br>Loss(-1) SSE in yield 0.000E+00<br>Loss(0) Penalty for B1 > K 0.000E+00 1 N/A 0.000E+00 N/A<br>Loss(1) CPUE from fishery, Yield 1.078E+01 45 2.508E-01 1.000E+00 1.208E+00 0.478<br>Loss(2) Series 2 1.421E+01 45 3.305E-01 1.000E+00 9.166E-01 0.399<br>Loss(3) Series 3 1.893E+01 45 4.402E-01 1.000E+00 6.883E-01 0.493<br>Loss(4) Series 4 1.098E+01 45 2.552E-01 1.000E+00 1.187E+00 0.425<br>TOTAL OBJECTIVE FUNCTION, MSE, RMSE: 5.48999460E+01 3.155E-01 5.617E-01<br>Estimated contrast index (ideal = 1.0): 0.4300 C* = (Bmax-Bmin)/K<br>Estimated nearness index (ideal = 1.0): 1.0000 N* = 1 - \|min(B-Bmsy)\|/K |
| Generalized Estimate Exponent model | Loss component number and title \| Weighted SSE \| N \| Weighted MSE \| Current weight \| Inv. var. weight \| R-squared in CPUE<br>Loss(-1) SSE in yield 0.000E+00<br>Loss(0) Penalty for B1 > K 0.000E+00 1 N/A 0.000E+00 N/A<br>Loss(1) CPUE from fishery, Yield 1.142E+01 45 2.655E-01 1.000E+00 1.435E+00 0.279<br>Loss(2) Series 2 2.224E+01 45 5.171E-01 1.000E+00 7.367E-01 0.165<br>Loss(3) Series 3 2.088E+01 45 4.856E-01 1.000E+00 7.846E-01 0.248<br>Loss(4) Series 4 1.569E+01 45 3.649E-01 1.000E+00 1.044E+00 0.197<br>TOTAL OBJECTIVE FUNCTION, MSE, RMSE: 7.02267613E+01 4.059E-01 6.371E-01<br>Estimated contrast index (ideal = 1.0): 0.3133 C* = (Bmax-Bmin)/K<br>Estimated nearness index (ideal = 1.0): 0.8848 N* = 1 - \|min(B-Bmsy)\|/K |

The estimates of MSY, $B_{MSY}$, $F_{MSY}$, $f_{MSY}$ for each fleet are shown in Table 1.6.4.3. The estimates of MSY and $F_{MSY}$ ranges after bootstrapping using approximate 80% upper and lower confidence limits are shown in Table 1.6.4.4.

**Table 1.64.3. Estimated parameters of picarel in GSA 22 & 23.**

| Model | MSY (tons) | $B_{MSY}$ (tons) | $F_{MSY}$ | $f_{MSY}$ Beach seine | $f_{MSY}$ Trawl | $f_{MSY}$ Purse seine | $f_{MSY}$ Small scale |
|---|---|---|---|---|---|---|---|
| **Logistic** | 5173 | 25140 | 0.21 | 6.05E+06 | 1.49E+08 | 5.81E+07 | 1.44E+08 |
| **Fox** | 5580 | 18500 | 0.30 | 4.88E+06 | 1.13E+08 | 4.44E+07 | 1.10E+08 |
| **GEE** | 6305 | 24850 | 0.25 | 4.43E+06 | 1.09E+08 | 4.28E+07 | 1.06E+08 |

**Table 1.6.4.4. Estimates of MSY and $F_{MSY}$ from bootstrapped analysis in ASPIC with confidence limits.**

| Model | MSY | | | $F_{MSY}$ | | |
|---|---|---|---|---|---|---|
| | 80% lower | | 80% higher | 80% lower | | 80% higher |
| **Logistic** | 5166 | 5173 | 5182 | 0.2055 | 0.2058 | 0.2061 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Fox** | 5452 | 5580 | 5902 | 0.2948 | 0.2992 | 0.3191 |
| **GEE** | 5669 | 6305 | 6891 | 0.2205 | 0.2537 | 0.2605 |

The relative biomass ($B/B_{MSY}$) and fishing mortality ($F/F_{MSY}$) are showed in Figure 1.6.4.5 for the three models.

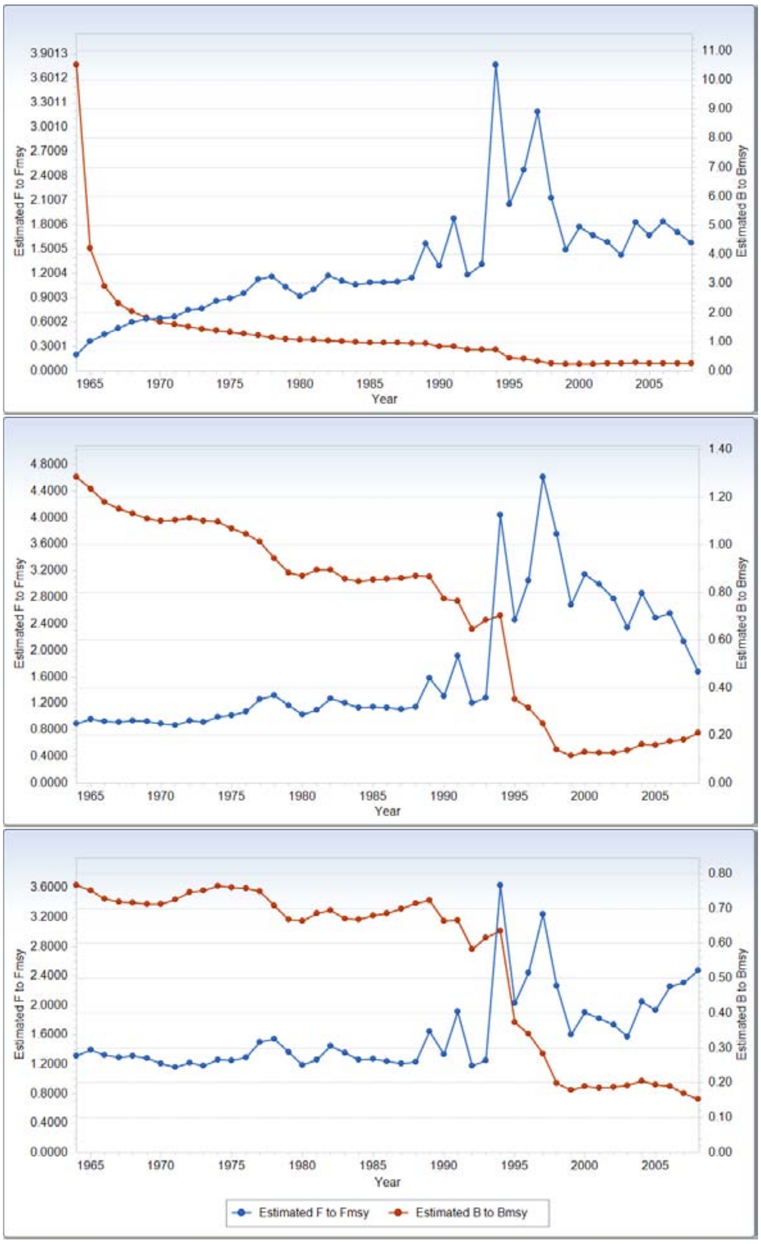



**Fig.1.6.4.5. Historic trend in estimated fishing mortality as $F/F_{MSY}$ ratio and biomass as $B/B_{MSY}$ ratio from Logistic (upper grapf), Fox (middle graph) and Generalized Estimate Exponent (lower graphs) models.**

The results of the production models suggest that picarel in the GSA 22&23 is overexploited, considering that the current F is from 1.5 to 2.4 times above the $F_{MSY}$ ($F/F_{MSY}$ = 1.63 from the Fox model). The biomass at sea, after five decades of higher exploitation, is below the $B_{msy}$, with the current B being from 0.5% to 20% of the $B_{MSY}$ ($B/B_{MSY}$ = 0.21 from the Fox model).

#### 1.6.4.2 Method 2: SURBA

***Justification***

The relatively long time series of data available from the MEDITS surveys provided the most useful data sets for analysis. The survey-based stock assessment approach SURBA (Needle, 2003) was used on MEDITS (1994-2009) data for *S. smaris* in GSAs 22&23. Length was converted to ages based on the growth equation presented in Tab. 1.6.4.5 for both sexes (Tsangridis, and Filippousis, 1991). Age groups 0 to 6 were identified. However, age group 0 was considered largely under sampled and ages 5 to 6 were merged as a plus group. Thus ages 1 to 5+ were used for analysis. Mean weight at age was a weighted mean based on the length frequency distribution of each age class. Average values were used for the years with missing info. Natural mortality were estimated as a vector for each age group based on ProdBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. Fref was set for ages 1 to 4. The entire data series (1994-2008) seems to split into 2 separate groups: one prior to 1999 presenting a very small number of catches and one after 1999 that looks more consistent with a high number of catches in all age classes. This is likely to be related to the unsuitability of the MEDITS survey for coastal, shallow waters species like picarel presenting low catchability values. The series for the period 1999-2008 was chosen for analysis. In addition a catchability pattern was defined assuming In addition a catchability pattern was defined assuming catchability q to 0.1, 0.75, 0.8 and 0.9 for ages 1, 2, 3 and 4 and 1 for age 5+.

***Input parameters***

**Tab. 1.6.4.5. Number at age of picarel in GSA 22&23 from MEDITS survey.**

| **Survey indexes (n/h)** | Age 1 | Age 2 | Age 3 | Age 4 | Age 5+ |
|---|---|---|---|---|---|
| 1999 | 1.0017 | 0.3242 | 0.2832 | 0.0582 | 0.2082 |
| 2000 | 0.6333 | 0.4222 | 0.1569 | 0.0158 | 0.0434 |
| 2001 | 1.272 | 0.5996 | 0.3774 | 0.3259 | 0.2189 |
| 2002 | -99 | -99 | -99 | -99 | -99 |
| 2003 | 1.5011 | 1.6829 | 0.7686 | 0.0933 | 0.1695 |
| 2004 | 2.9239 | 1.3602 | 0.8341 | 0.3319 | 0.6231 |
| 2005 | 2.2548 | 1.6341 | 1.1664 | 0.4742 | 0.3253 |
| 2006 | 2.146 | 1.5064 | 0.5121 | 0.2786 | 0.4554 |
| 2007 | -99 | -99 | -99 | -99 | -99 |
| 2008 | 0.3411 | 0.4638 | 0.2418 | 0.1911 | 0.5216 |

Not available data due to the lack of survey are indicated as -99.

**Table 1.6.4.6. Weight at age in the stock (in kg) of *Spicara smaris* in GSA 22&23 for 1999-2008.**

| | Age 1 | Age 2 | Age 3 | Age 4 | Mean Age 5+ |
|---|---|---|---|---|---|
| 1999 | 0.00775 | 0.01235 | 0.01955 | 0.02697 | 0.03632 |
| 2000 | 0.00694 | 0.01238 | 0.01922 | 0.02697 | 0.03576 |
| 2001 | 0.00606 | 0.01262 | 0.02099 | 0.02697 | 0.03660 |
| 2002 | 0.00828 | 0.01386 | 0.02127 | 0.02783 | 0.03756 |
| 2003 | 0.00811 | 0.01231 | 0.01938 | 0.02697 | 0.03600 |
| 2004 | 0.00690 | 0.01253 | 0.02018 | 0.02697 | 0.03823 |
| 2005 | 0.00664 | 0.01285 | 0.02043 | 0.02697 | 0.03688 |
| 2006 | 0.00752 | 0.01191 | 0.02026 | 0.02697 | 0.03777 |
| 2007 | 0.00828 | 0.01386 | 0.02127 | 0.02783 | 0.03756 |
| 2008 | 0.00837 | 0.01249 | 0.02060 | 0.02697 | 0.03907 |

Growth parameters (Tsangridis, and Filippousis, 1991)

| $L_\infty$ | k | $t_0$ |
|---|---|---|
| 196 cm | 0.23 $y^{-1}$ | -1.97 y |

| Length-weight relationships | |
|---|---|
| a | b |
| 0.00001 | 2.9001 |

| Maturity at Age (based on GSA 25 estimates) | | | | |
|---|---|---|---|---|
| Age 1 | Age 2 | Age 3 | Age 4 | Mean Age 5+ |
| 0.85 | 0.9 | 0.85 | 0.97 | 0.96 |

| Natural mortality (M) | | | | |
|---|---|---|---|---|
| Age 1 | Age 2 | Age 3 | Age 4 | Mean Age 5+ |
| 0.518431 | 0.44933 | 0.42127 | 0.406051 | 0.390538 |

***Results***

The residual plots of log catchabilities show no apparent pattern and adequate model fit. The highest residuals were observed in 2000 and 2001 for ages 4 and 5+.

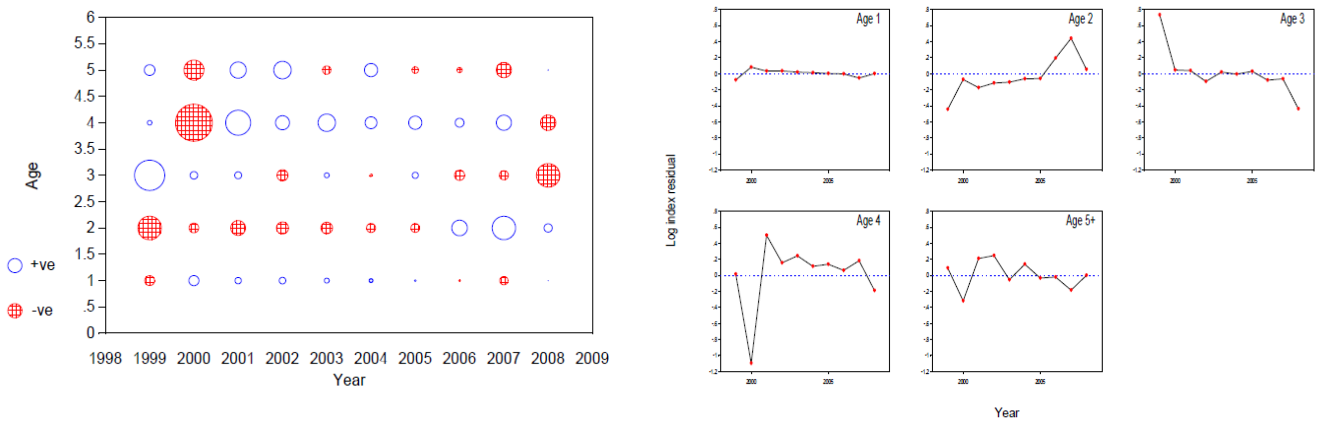



**Fig. 1.6.4.6. Residual plot of log index catchabilities per age and year of *Spicara smaris* SURBA model for GSA 22&23 (1999-2008).**

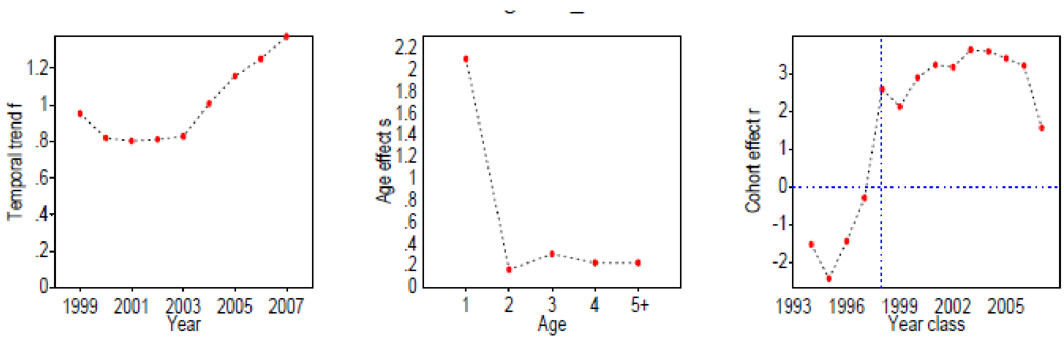



**Fig. 1.6.4.7. MEDITS survey. Fitted year, age and cohort effects estimated by SURBA.**

Fitted year effect, that is the model proxy for the combination of fishing effort and mean natural mortality in the underlying population, shows an increase after 2003. Fitted age effect shows a decrease from age 1 to age 2 becoming very low at ages 3 to 5+, while fitted cohort effect shows no apparent trend (Figure 1.6.4.7).

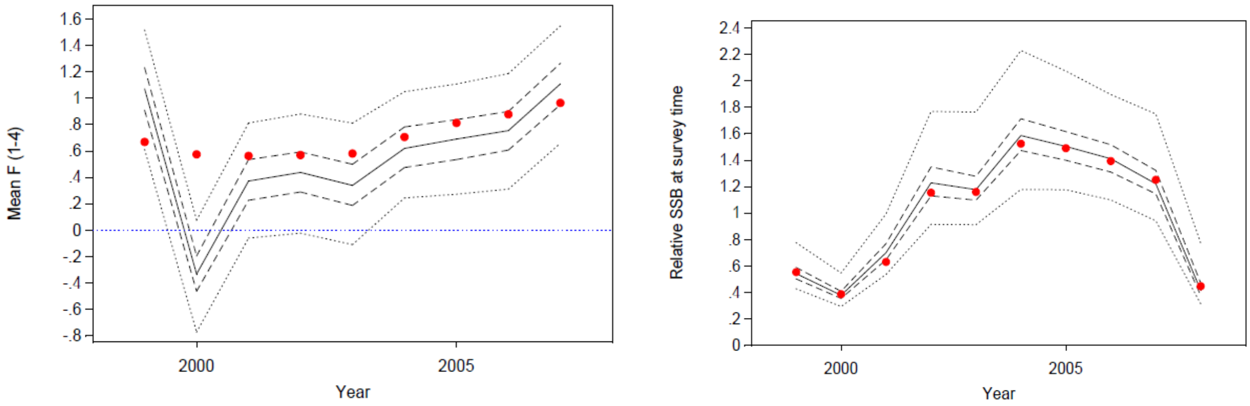
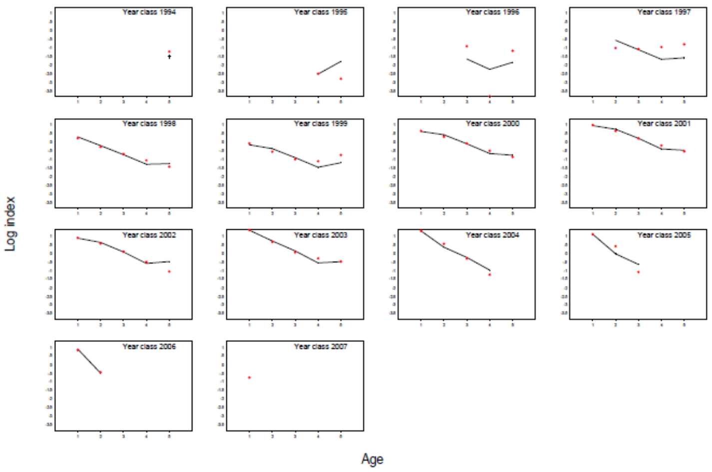



**Fig. 1.6.4.8. MEDITS survey. Estimated trend in F and relative SSB using SURBA. 50th percentile of bootstrapped runs (solid line) and 5% and 95% percentiles of bootsrapped runs (dashed lines).**

The model estimates an increase in mean F after 2001. An increase in SSB and recruitment is also observed after 2001 and a fall is estimated after 2007 (Fig. 1.6.4.8).

Model diagnostics are shown in the following Fig. 1.6.4.9. Retrospective analysis was applied in the SURBA model for the 1999-2008 period with 5 years backward analysis. Results are presented in Fig 1.6.4.10 and show no particular retrospective bias. Some bias was identified in the age effect and the temporal trend. The lack of years prior to 1999 is influential for the estimation of the 1997 cohort. The assessment generally cannot be considered reliable since age cohorts present a poor fit, estimated index for F, SSB and recruitment are highly irregular. In addition the analysis is largely driven by the selected catchability pattern.



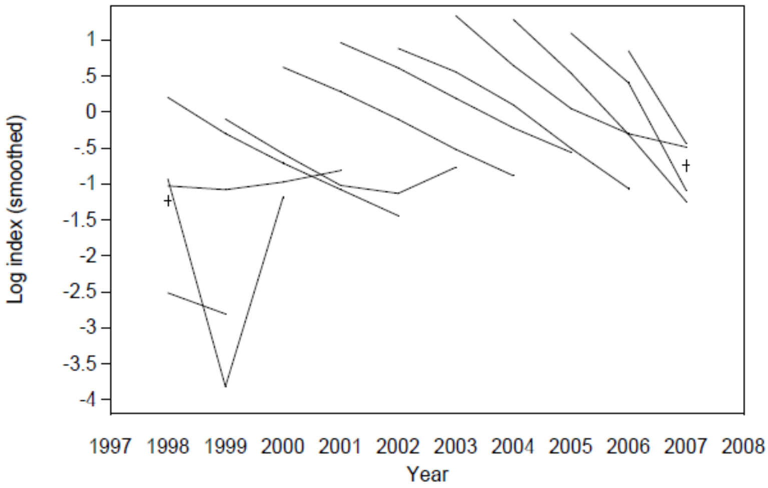



**Fig. 1.6.4.9. Model diagnostics for *Spicara smaris* SURBA model in the GSA 22&23 (MEDITS data). Top: Comparison between observed (points) and fitted (lines) survey abundance indices, for each year.**

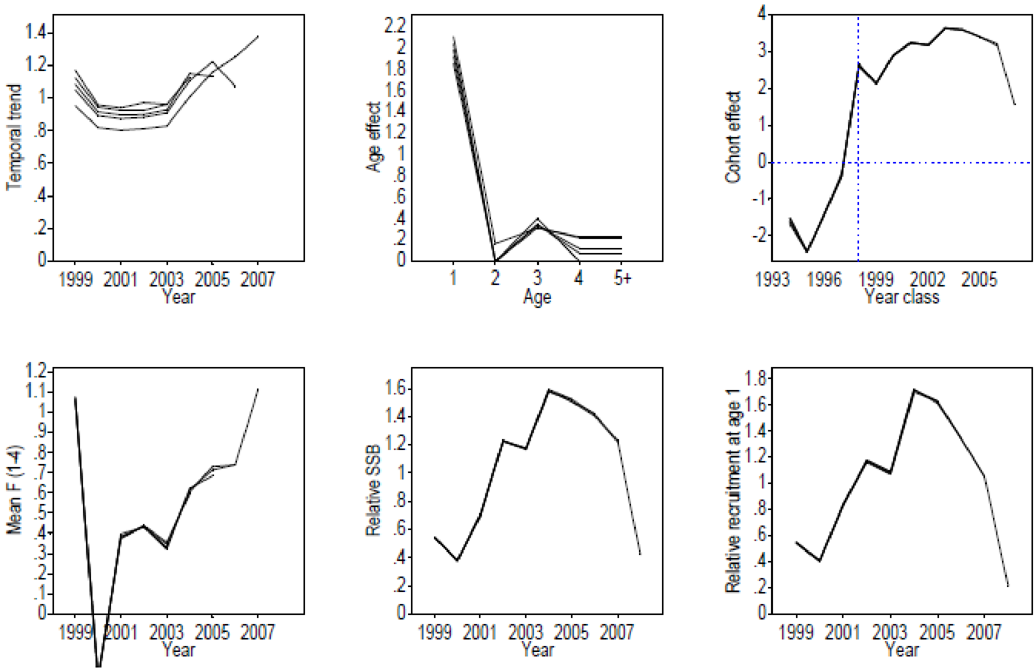



**Fig. 1.6.4.10. Model diagnostics for *Spicara smaris* SURBA model in the GSA 22&23 (MEDITS data). Results of retrospective analysis with 5 years period.**

## 1.6.5 *Long term prediction*

Justification

### 1.6.5.1 Results

In Table 1.6.5.1 are showed the management reference points as estimated by ASPIC.

**Table 1.6.5.1. Reference points.**

| | |
|---|---|
| Maximum sustainable yield (MSY; tons) | 5,580 |
| Stock biomass giving MSY ($B_{MSY}$; tons) | 18,500 |
| Fishing mortality rate at MSY ($F_{MSY}$) | 0.30 |

## 1.6.6 *Scientific advice*

### 1.6.6.1 Short term considerations

***State of the spawning stock size***

In the absence of proposed or agreed precautionary reference is not possible to fully evaluate the status of the spawning stock size. SURBA results, due to the poor data fit, are not considered reliable to evalute the status of the spawning stock size.
The total biomass at sea in 2008 estimated with the production model using the Fox approach, is, about 20% of $B_{MSY}$ ($B/B_{MSY}$ = 0.21).

***State of recruitment***

SURBA results, due to the poor data fit, are not considered reliable to evalute the status of the recruitment.

***State of exploitation***

The values of current F estimated by ASPIC with the Fox model ($F/F_{MSY}$ = 1.67) suggests that picarel in GSA 22&23 is exploited unsustainably. SURBA results due to the poor fit, are not considered reliable to evalute the status of the exploitation.

### 1.6.6.2 Data quality

The data used in the production model are estimates of landings of picarel and effort for GSA 22 & 23 provided by Moutopoulos and Stergiou (2012) FAO-FISHSTAT GFCM database. Discard data were not available for this stock, as well as maturity and growth information. The FAO-FISHSTAT GFCM database has been consulted in order to have an indication of the picarel landings in GSA 22 from the Turkish fleets Considering the low amount of landings of picarel from Turkey, they were not considered in the model. MEDITS survey seems to be unsuitable for picarel since the survey design is not adjusted for coastal shallow water species.

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## 1.7 **Stock assessment of *Nephrops norvegicus* in GSA 20**

### 1.7.1 *Stock identification*

Norway lobster, *Nephrops norvegicus*, is an epibenthic species inhabiting muddy bottoms in which it digs burrows. It is found at depths ranging from 20 - 800 m, usually 200 - 600 m. It is distributed in the Eastern Atlantic, from Iceland to northwestern Norway and south to the Atlantic coast of Morocco, and the Mediterranean Sea. It feeds on detritus, crustaceans and worms. It is highly commercial (more info and refs in www.sealifebase.org).

### 1.7.2 *Fisheries*

***Management regulations applicable in 2010 and 2011***

There are not any special management regulations enforced for this species apart from the general ones applied throughout the Greek Seas.

***Landings***

It represents less than 0.2% of the total landings of the four different gears examined in this study (trawls (OTB), purse seines (PS), beach seines (SV), gill nets and long lines (GNS and LLS) in GSA20 (see Table 3 from section 1 of this report and Moutopoulos and Stergiou, 2012). Its annual landings per gear in GSA 20 are less than 40 t. Landings varied considerably during 1964-2007 for all gears with trawl landings exhibiting peaks in mid 1980s, late 1990s and late 2000s whereas the landings of the small scale vessels exhibited peaks in mid 1980s, early 2000s and declined thereafter (see Figure 2 from section 1 of this report).

***Discards***

Given that *Nephrops norvegicus* is highly commercial, discards are extremely low or nil. Theoretically, discards should be limited only to undersized specimens caught since there is a minimum landing size of 20 mm carapace length and 70 mm total length. However, it is rather doubtful that such individuals are discarded.

***Fishing effort***

The fishing effort for the gears implicated in the fisheries has been presented in section 1 of this report.

### 1.7.3 *Assessment of historic stock parameters*

#### 1.7.3.1 Method 1: Production model-ASPIC

***Justification***

A production model has been employed in order to estimate the fishing mortality and the biomass at sea and the relative reference points in term of $F_{MSY}$ and $B_{MSY}$, using the catch and effort data estimated as in section 1 of this report.

***Input parameters***

A non-equilibrium dynamic biomass model incorporating covariates [ASPIC 5.10.1] (Prager 2005) was applied to catch and effort (hP x Days) data from the GSAs 20. Landings data for OTB and GNS and LLS were referred to the period 1982-2007 due to zero landings during 1964-1981 for OTB. The logistic model was used. In addition to data on catch and effort, ASPIC requires starting guesses and ranges for the parameters to be estimated by the model: carring capacity (K), maximum sustainable yield (MSY), the ratio of the biomass at the beginning of the first year to the carrying capacity (B1/K) and catchability (q) (Table 1.7.3.1.).

**Table 1.7.3.1. ASPIC input parameters of the FIT mode for *N. norvegicus* in GSA 20.**

| B1/K | MSY | Range of MSY | K | Range of K | Fishing fleet | q (mean (CPUE) / 2*max(Y)) |
|---|---|---|---|---|---|---|
| 2.86E-02 | 9.795E+01 | 8.0E+00 - 2.0E+02 | 5.356E+02 | 1.0E+01 - 5.0E+03 | OTB | 3.220E-08 |
| | | | | | GTR | 2.100E-08 |

After fitting the values for the above parameters, the FIT mode is run. At this point ASPIC computes estimates of parameters, including time trajectories of fishing intensity and stock biomass. The results of the fit were used to compute bias-corrected approximate confidence limits (80% CL) through bootstrap analysis. The model fittings are under the assumption that yield in each year is known more precisely than fishing effort or relative abundance from MEDITS survey, which has been discarded from the model because did not provide a better fit. In other words, all model fittings were conditioned on yield, rather than on effort or relative abundance (Prager 2005).

If there is normal convergence, the point estimates of the FIT mode were loaded in the BOT mode for bootstrapping. In this mode the software computes bootstrap confidence intervals on estimated quantities. This approach resamples the residuals from the optimum fit to generate new bootstrap samples of the observed time series. The residuals between the observed and predicted catch rates (CPUE), are used for bootstrap analysis. Bootstrap data sets are constructed by combining predicted CPUE with a randomly chosen residual to compute a pseudo-CPUE value. The model is then refit, using the pseudo-CPUE, which is assumed to relate back to stock biomass via the catchability coefficient (CPUE = qBt). The process is repeated at least 1000 times (bootstrap trials) for each different fit. At each trial the objective function used is the sum of squared errors (Haddon 2001, Prager 2005).

***Results***

Initial runs in the ASPIC FIT mode and the observed CPUE and predicted CPUE indexes are shown in Figure 1.7.3.1. A stable pattern in predicted CPUE is observed for all the runs, especially after 1992.


**Fig.1.7.3.1. Observed and predicted values of CPUE of *N. norvegicus* in GSA 20 for OTB and GRT using the dynamic non-equilibrium Logistic model in ASPIC for the period 1982-2007.**

In the logistic model the estimated biomass and fishing mortality fluctuated respectively from 16.16 to 48.73 t and from 0.55 to 0.78 (Figure 1.7.3.2).

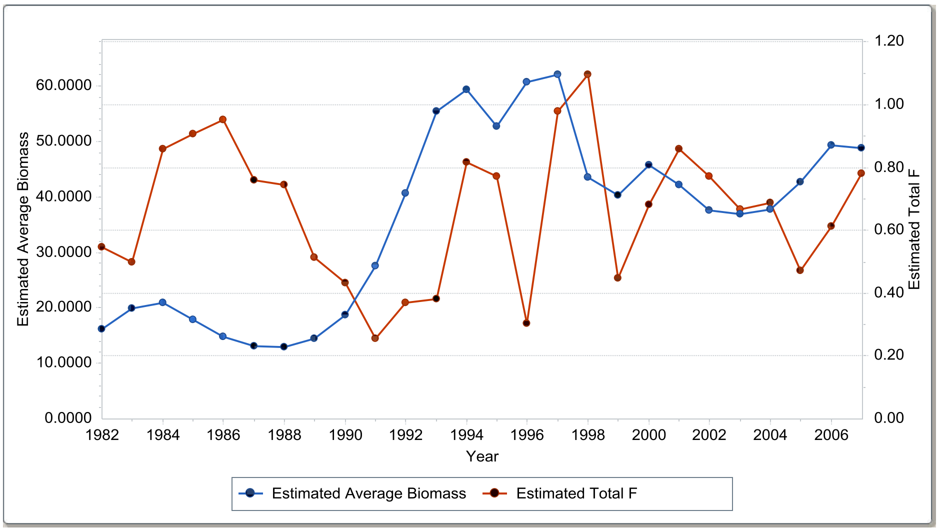



**Fig.1.7.3.2. Estimated average biomass and fishing mortality of *N. norvegicus* in GSA 20 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1982-2007.**

The goodness of fit of each model is presented in Table 1.7.3.2. The logistic model presented a general a better, but low, fit for OTB than for GTR.

**Table 1.7.3.2. Goodness of fit results for the logistic model in ASPIC.**

| Loss component number and title | Weighted SSE | N | Weighted MSE | Current weight | In. var. weight | R-squared CPUE |
|---|---|---|---|---|---|---|
| Loss(-1) SSE in yield | 0.00E+00 | | | | | |
| Loss(0) Penalty for B1 > K | 0.00E+00 | 1 | | 1.00E+00 | | |
| Loss(1) OTB | 3.723E+01 | 26 | 1.551E+00 | 1.00E+00 | 2.854E-01 | 0.263 |
| Loss(2) GTR | 6.196E+00 | 26 | 2.582E-01 | 1.00E+00 | 1.715E+00 | 0.104 |
| TOTAL OBJECTIVE FUNCTION, MSE, RMSE: | 4.343E+01 | | 8.685E-01 | 9.320E-01 | | |
| Estimated contrast index (ideal = 1.0): | 0.1158 | | C* = (Bmax-Bmin)/K | | | |
| Estimated nearness index (ideal = 1.0): | 0.6408 | | N* = 1 - \|min(B-Bmsy)\|/K | | | |

The estimates of MSY, $B_{MSY}$, $F_{MSY}$, $f_{MSY}$ for GTR are shown in Table 1.7.3.3 and the estimates of MSY and $F_{MSY}$ ranges after bootstrapping using approximate 80% upper and lower confidence limits are shown in Table 1.7.3.4.

**Table 1.7.3.3. Estimated parameters of Nephrops in GSA 20.**

| Model | MSY (tons) | $B_{MSY}$ (tons) | $F_{MSY}$ | B(2008)/Bmsy | F(2007)/Fmsy | $f_{MSY}$ OTB | $f_{MSY}$ GTR |
|---|---|---|---|---|---|---|---|
| Logistic | 9.730E+01 | 2.568E+02 | 3.788E-01 | 1.808E-01 | 2.065E+00 | 1.176E+07 | 1.804E+07 |

**Table 1.7.3.4. Estimates of MSY and $F_{MSY}$ from bootstrapped analysis in ASPIC with confidence limits.**

| Model | | MSY | | | $F_{MSY}$ | |
|---|---|---|---|---|---|---|
| | 80% lower | | 80% higher | 80% lower | | 80% higher |
| Logistic | 9.629E+01 | 9.730E+01 | 9.769E+01 | 3.710E-01 | 3.788E-01 | 3.995E-01 |

The relative biomass ($B/B_{MSY}$) and fishing mortality ($F/F_{MSY}$) are showed in Figure 1.7.3.3 for the logistic model.

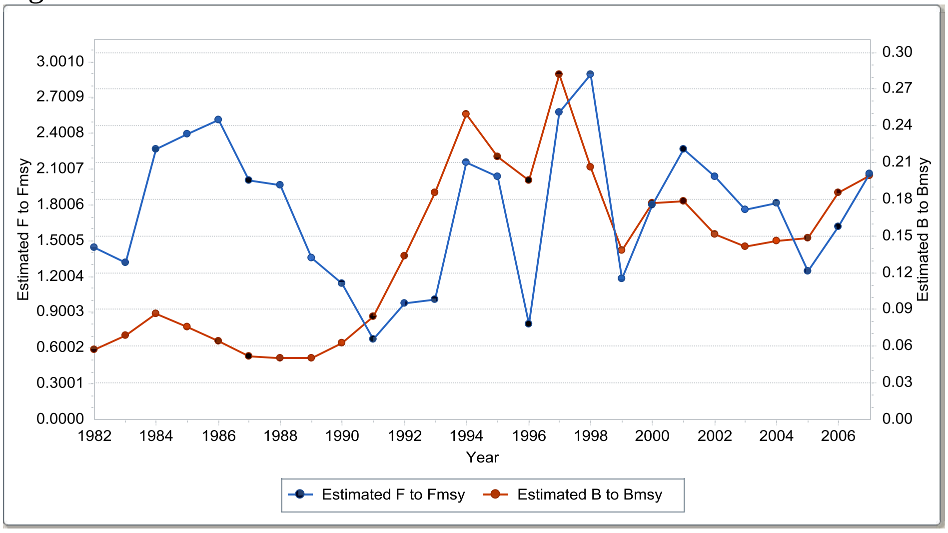



**Fig.1.7.3.3. Historic trend in estimated fishing mortality as $F/F_{MSY}$ ratio and biomass as $B/B_{MSY}$ ratio from Logistic model.**

The results of the production models suggest that GTR fishery of Nephrops in the GSA 20 is an overexploited stage, considering that the current F is 2.065 times above the $F_{MSY}$. In addition, the biomass at sea, is below the $B_{MSY}$, with the ratio of current B to $B_{MSY}$ being 0.1808.

### 1.7.3.2 Method 2: SURBA (Survey Based Assessment)

***Justification***

Although the relatively long time series of data available from the MEDITS surveys should provide useful data set to analyse the trend of *Nephrops norvegicus* stock in GSA 20, the problems found in the data avoid a reliable assessment of the status of these species based on survey data. For 1994-1995, size distribution showed inconsistent values (Fig 1.7.3.4) so they were removed. For the rest of the years, the number of individuals measured ranged between 16 and 207 (Table 1.7.3.4), with several years with less than 100 individuals. Thus, the number of individuals is considered too low to obtain a consistent size distribution.

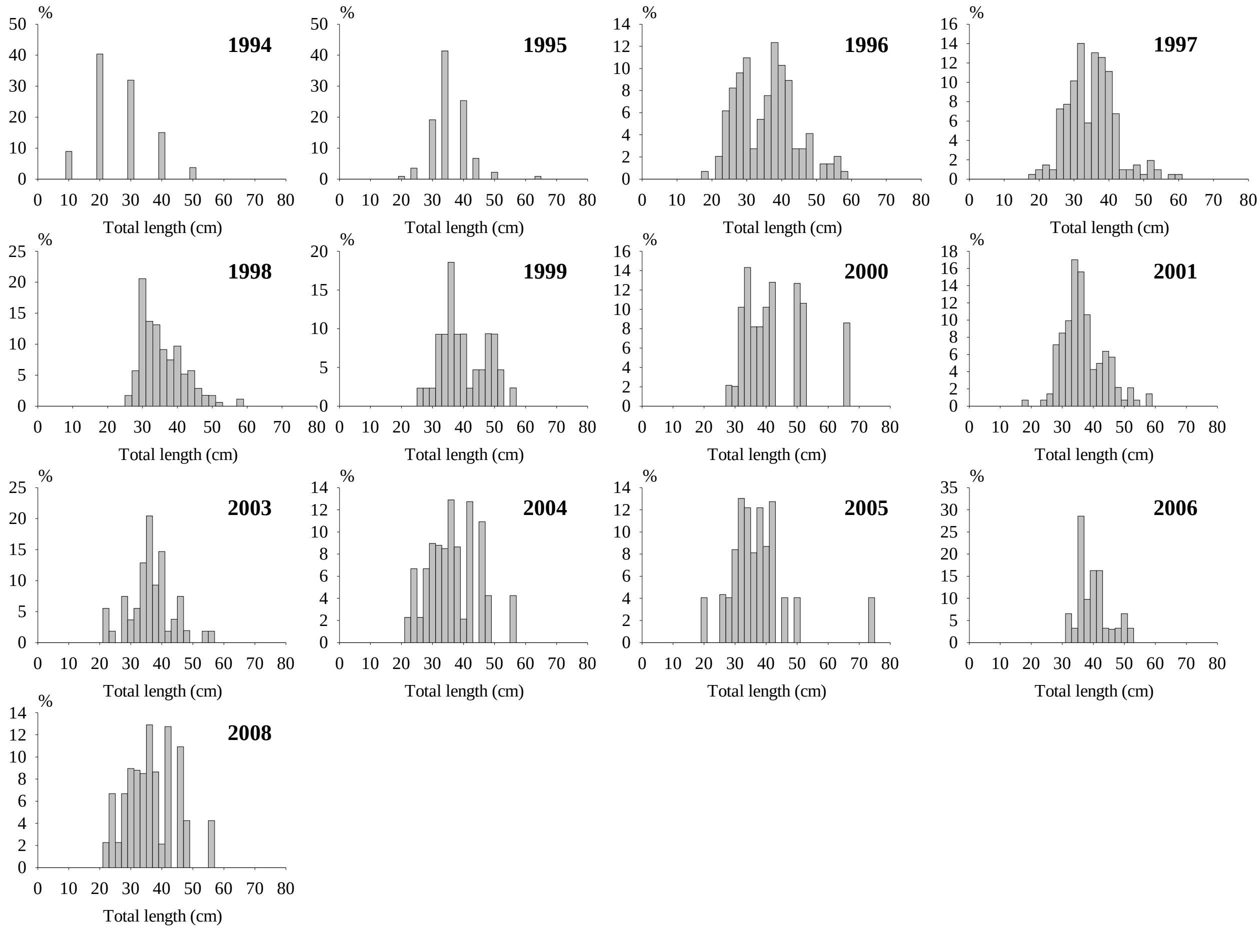



**Fig. 1.7.3.4. MEDITS length frequency distributions of Norway lobster in the GSA 20.**

**Table 1.7.3.4. Number of individuals measured by year for Norway lobster in the GSA 20.**

| 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2003 | 2004 | 2005 | 2006 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|
| 147 | 207 | 176 | 43 | 49 | 141 | 61 | 61 | 33 | 48 | 16 |

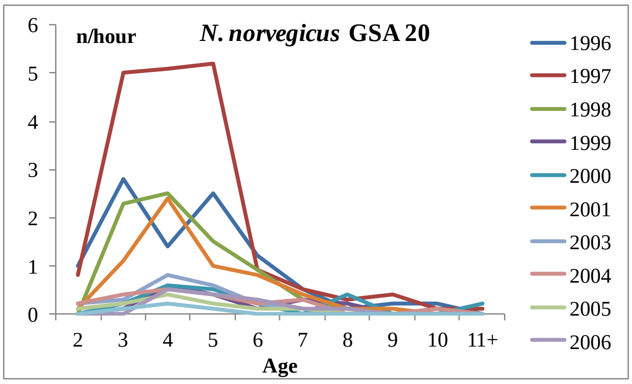



**Fig. 1.7.3.5. Numbers at age distributions of Norway lobster or MEDITS 1996-2008 in GSA 20.**

***Input parameters***

Table 1.7.3.5 shows the input parameters used to run SURBA.

Single survey exploratory SURBA 2.2 model runs were carried out fitting constant catchability (1.0 for all ages)

The model settings are given below:
Year range: 1996-2008, 2002 and 2007 lacking
Age range: 2-11+
Age weighting: 0.8 (age 2), 1 (ages 3-6), 0.60 (age 7-11+)

**Table 1.7.3.5. Input parameters of SURBA.**

**Growth parameters**

| L∞ | k | t0 | a | b |
|---|---|---|---|---|
| 78.05 | 0.131 | -0.426 | 0.000373 | 3.1576 |

**Proportion of mature**

| Age | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11+ |
| 0.153 | 0.345 | 0.573 | 0.756 | 0.866 | 0.924 | 0.957 | 0.972 | 0.983 | 0.988 |

**Natural mortality**

| Age | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11+ |
| 0.303 | 0.249 | 0.219 | 0.198 | 0.191 | 0.182 | 0.175 | 0.17 | 0.166 | 0.165 |

***Results***

Comparative scatterplots at age indicated good consistency of the MEDITS data for all ages combinations (Fig. 1.7.3.6).

The trends in F, SSB and recruitment at age 0 from SURBA run, and the model residuals are given in Figures 1.7.3.7-9. SURBA estimated large oscillations in the temporal effect (f), with a general decreasing trend. The age effect showed the highest values for ages 4-6.
Total mortality (Z) showed oscillations with maximum values for 1996 and 2008. F (bootstrapped estimates) also showed these oscillations. Both SSB and the estimated relative SSB showed a clear decreasing trend.

The residuals at age did not show any trend, except for age 2.

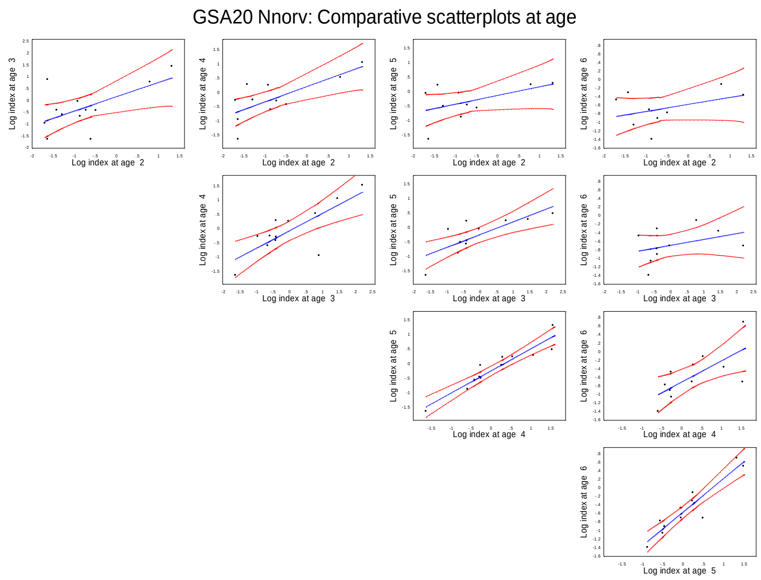
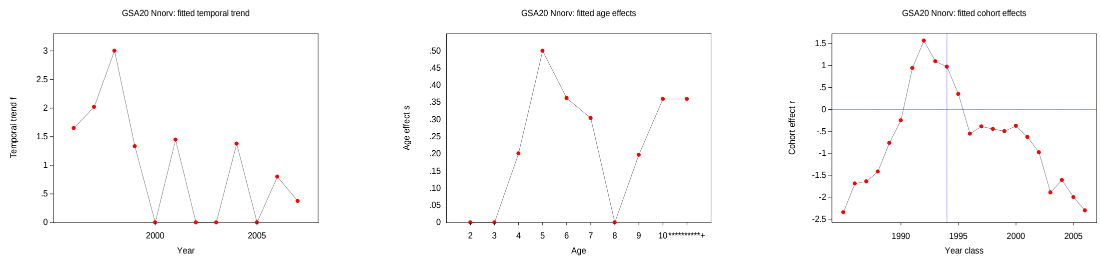
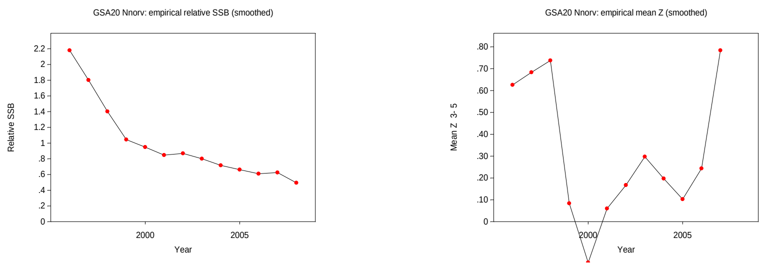



**Fig. 1.7.3.6. Norway lobster in GSA 20: Output from SURBA plots for MEDITS survey, showing age scatter plots.**

A)




B)




C)

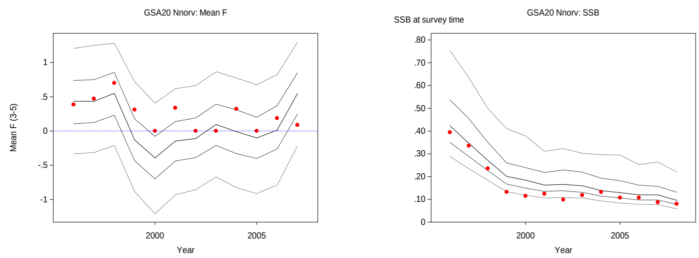
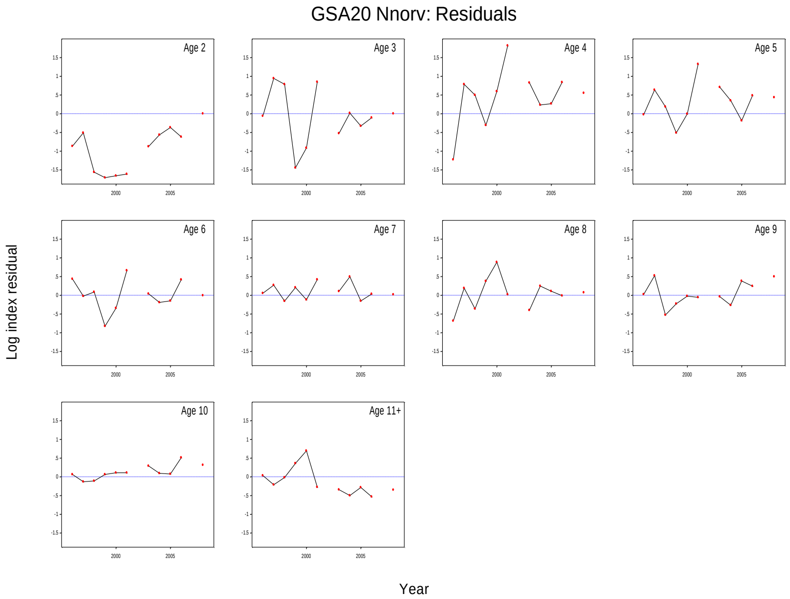


**Fig. 1.7.3.7. SURBA estimates for Norway lobster in GSA 20. A) model parameters. B) total mortality and SSB C) bootstrapped (lines) and fitted (points) estimates of $F_{1\text{-}2}$ and SSB, and empirical relative SSB, solid and dotted lines are respectively 50% and 5- 95% of bootstrapped estimates.**

A)




B)

**Fig. 1.7.3.8. SURBA model diagnostic for Norway lobster in GSA 20. A) Temporal trend in residuals by age B) Observed (points) and fitted (lines) year classes.**

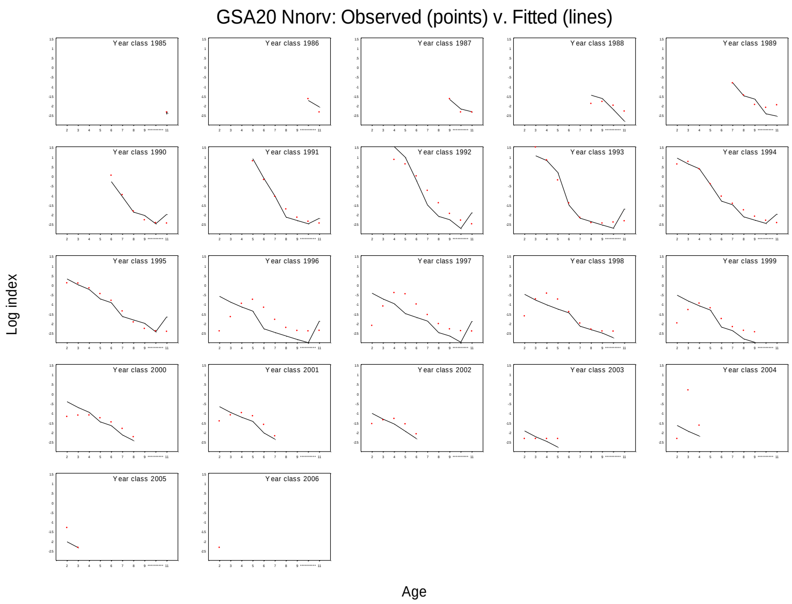



**Fig. 1.7.3.9. SURBA model of Norway lobster in GSA 20: cohorts fitting.**

The model is not able to fit the cohorts (Fig. 1.7.3.9) and give inconsistent results in terms of F. Also, the model is based on a very low number of individual per year (around 100 or less). Thus, the results of SURBA are not considered reliable for providing advice on the status of Norway lobster in GSA 20. This is also the reason for which the figure for the retrospectives for the MEDITS survey is not included as data are not reliable enough to perform an analysis.

### 1.7.4 *Short term prediction for 2008 and 2009*

#### 1.7.4.1 Justification

No forecast analyses were conducted.

#### 1.7.4.2 Input parameters

No forecast analyses were conducted.

### 1.7.5 *Medium term prediction*

#### 1.7.5.1 Justification

No forecast analyses were conducted.

#### 1.7.5.2 Input parameters

No forecast analyses were conducted.

#### Results

### 1.7.6 *Long term prediction*

#### Justification

No forecast analyses were conducted.

#### 1.7.6.1 Input parameters

No forecast analyses were conducted.

#### 1.7.6.2 Results

### 1.7.7 *Scientific advice*

Production models showed that Norwey lobster in GSA 20 is exploited unsustainably. F is larger than $F_{MSY}$ ($F/F_{MSY}$ = 2.06) and the biomass is below $B_{MSY}$ ($B/B_{MSY}$ = 0.18).

***State of the spawning stock size***

In the absence of proposed or agreed precautionary reference is not possible to fully evaluate the status of the spawning stock size. SURBA assessment cannot be considered reliable since age cohorts present a poor fit.
The total biomass at sea in 2008 estimated with the ASPIC production model is about 20% of $B_{MSY}$ ($B/B_{MSY}$ = 0.18).

***State of recruitment***

SURBA assessment cannot be considered reliable for assessing the status of recruiment since age cohorts present a poor fit.

***State of exploitation***

The values of current F estimated by ASPIC with the logistic model ($F/F_{MSY}$ = 2.06) suggests that Norway lobster in GSA 20 is exploited unsustainably. SURBA assessment cannot be considered reliable for assessing the status of recruiment since age cohorts present a poor fit.

#### 1.7.7.1 Data quality

Survey data are derived from MEDITS surveys, which end in 2008. Data for the Surplus Production Models were derived from a reconstructed series back to 1964. However, no illegal and unreported landings (which might probably be high) are available. Given that this species extends in large depths and is caught with trawls it is very likely that abundance and assessments are affected by not including info from the fisheries of neighboring countries (e.g. Italy, Albania). For the rest of the years, the number of individuals measured during MEDITS ranged between 16 and 207, with several years with less than 100 individuals. Thus, the number of individuals is considered too low to obtain a consistent size distribution.

## REFERENCES

Haddon, M. 2001. Modelling and quantitative methods in fisheries. Chapman and Hall/CRC. New York.

Moutopoulos D.K., Stergiou K.I. 2012. Spatial disentangling of Greek commercial fisheries landings by gear between 1928-2007. Journal of Biological Research, 18: 265-279.

Prager, M.H. 2005. User’s Manual for ASPIC: Stock Production Model Incorporating Covariates (ver. 5) and Auxiliary Programs. National Marine Fisheries Service. Population Dynamic Team. CCFHR/NOCAA-North Carolina, USA

## 1.8 **Stock assessment of Norway lobster in GSA 22&23**

### 1.8.1 *Stock identification and biological features*

#### 1.8.1.1 Stock Identification

Due to the lack of information about the structure of Norway lobster (*Nephrops norvegicus*) population in the western Mediterranean, this stock was assumed to be confined within the GSA 22&23 boundaries.

*N. norvegicus* is a mud-burrowing species that prefers sediments with mud mixed with silt and clay in variable proportions. The emergence of individuals from burrows may vary depending on biological features and environmental factors (moult or reproduction cycles, light intensity, etc).

#### 1.8.1.2 Growth

Maximum observed size in GSA 22&23 was 68 mm. Growth parameters were those obtained from DCR data from Greek waters, while length-weight relationship used came from GSA 9, previously used in SGMED-STECF EWG:

$L_\infty$ =78.05 mm
K = 0.131
$T_0$= -0.426

Length-weight relationships: a = 0.000373; b = 3.1576

#### 1.8.1.3 Maturity

Maturity ogives used are these estimated for GSA 09.

| Age | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11+ |
| 0.02 | 0.05 | 0.15 | 0.35 | 0.57 | 0.75 | 0.86 | 0.92 | 0.96 | 0.97 | 1 | 1 |

### 1.8.2 *Fisheries*

#### 1.8.2.1 General description of fisheries

Norway lobster catches come primarily by trawling on the shelf of the northern Aegean, between 200 and 300 m depth with limited catch in other areas including slope grounds. On occasion, net fishermen may target Norway lobster by using baited nets (Smith and Papadopoulou, 2003).

***Management regulations***

From Gozalvo et al. (2011):

- Bottom trawl:
    - Minimum distance from the coast
    - Mesh size dimensions
    - Temporal closure
    - Minimum fishing depth
- Netters:
    - Maximum dimension of nets
    - Minimum mesh size
    - Type of thread

There are not any special management regulations enforced for this species apart from the general ones applied throughout the Greek Seas.

Catches

***Landings***

Landings of Norway lobster in GSA 22&23 come mostly from trawling, although catches from nets are also important. Trawl landings have oscillated between 500-700 t and net landings between 70-400 t (Fig. 1.8.2.1).

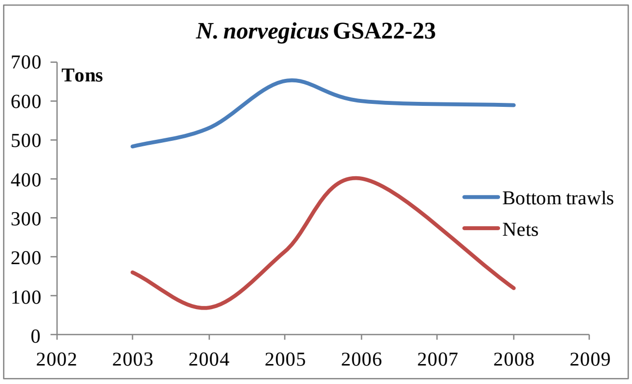



**Fig. 1.8.2.1. Landings of Norway lobster (trawling) in the GSA 22&23, from 2003 to 2008.**

Trawl landings are composed by specimens from 10 to 68 mm CL, while trap landings ranged between 26 and 64 mm CL (Fig. 1.8.2.2).

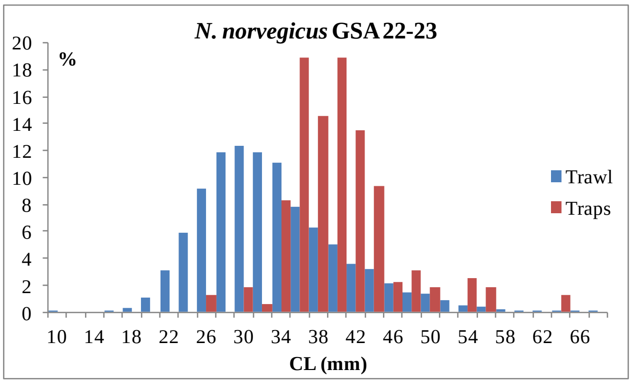



**Fig. 1.8.2.2. Size structure of the landings of *N. norvegicus* in 2003-2008 (mean value) caught by trawling and traps in the GSA 22&23.**

Landings of *N. norvegicus* represents less than 2.5% of the total landings of the four different gears examined in this study (trawls (OTB), purse seines (PS), beach seines (SV), gill nets and long lines (GTR) in GSA22&23 (see Table 3 from Section 1 of this report and Moutopoulos and Stergiou, 2012). However, only GTR annual landings in GSA 22&23 show a considerable amount fluctuating from 72.7 t to 339.2 t during 1970-2007.

***Discards***

Given that *Nephrops norvegicus* is highly commercial, discards are extremely low or nil. Theoretically, discards should be limited only to undersized specimens caught since there is a minimum landing size of 20 mm carapace length and 70 mm total length. However, it is rather doubtful that such individuals are discarded.

***Fishing effort***

The number of fishing trips for bottom trawl has been constant during the data series, with a slight decreasing trend (Fig. 1.8.2.3). On the contrary, fishing trips for nets has increased significantly. In fact, value for 2008 was 6 times higher than value for 2006. Pending confirmation of validity of this information, this value has not been represented.

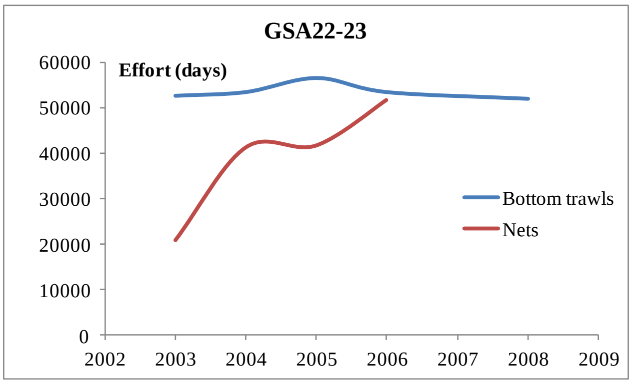



**Fig. 1.8.2.3. Number of fishing trips by fishing gear for GSA22&23.**

The fishing effort for the gears that catch *N. norvegicus* in GSA22&23 has been presented in Section 1 of this report.

1.8.3 *Scientific surveys*

1.8.3.1 MEDITS surveys

***Methods***

Since 1994, MEDITS trawl surveys has been regularly carried out each year during spring. Based on the DCR data call, abundance and biomass indices were calculated. In GSA 22&23 the following number of hauls was reported per depth stratum (Table 1.8.3.1).

**Table 1.8.3.1. Number of hauls per year and depth stratum in GSA22&23, 1994-2008.**

| DEPTH_STRATUM | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2003 | 2004 | 2005 | 2006 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 010-050 | 10 | 10 | 11 | 10 | 13 | 12 | 13 | 13 | 13 | 13 | 14 | 14 | 13 |
| 050-100 | 19 | 21 | 22 | 28 | 24 | 26 | 21 | 25 | 25 | 23 | 24 | 24 | 27 |
| 100-200 | 19 | 26 | 38 | 36 | 36 | 33 | 38 | 35 | 36 | 43 | 41 | 41 | 40 |
| 200-500 | 32 | 35 | 45 | 50 | 51 | 54 | 50 | 48 | 51 | 53 | 52 | 52 | 52 |
| 500-800 | 18 | 13 | 19 | 22 | 22 | 21 | 20 | 17 | 17 | 17 | 17 | 17 | 17 |

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma\ (Yi*Ai) / A$$
$$V(Yst) = \Sigma\ (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution and quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

***Geographical distribution patterns***

Figure 1.8.3.1 provides the distribution of sampling hauls of the MEDITS survey in GSA 20.

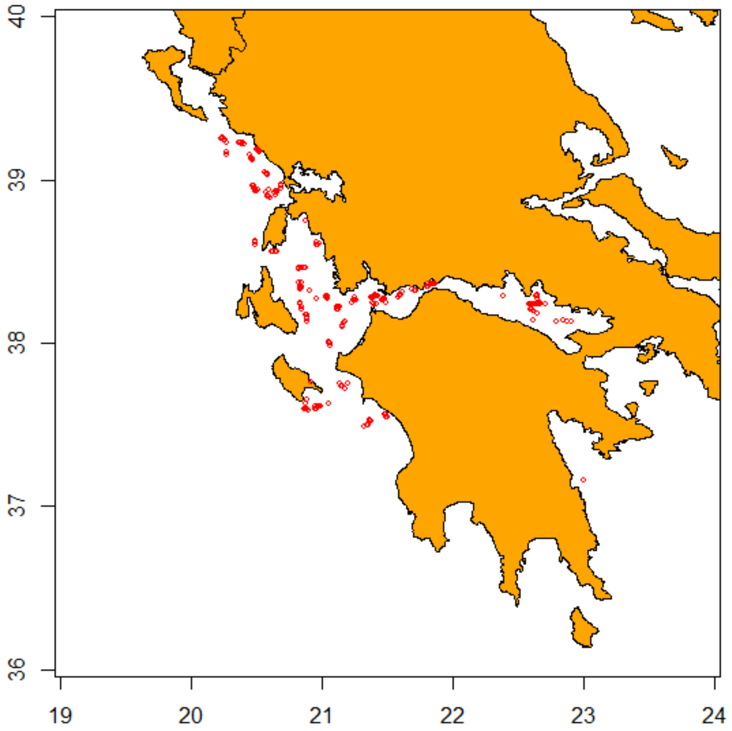



**Fig. 1.8.3.1. Distribution of sampling hauls of the MEDITS survey in GSA 20.**

***Trends in abundance and biomass***

Fig. 1.8.3.2 displays the biomass trends of Norway lobster in GSA 22&23. Biomass shows a clear decreasing trend along the data series.

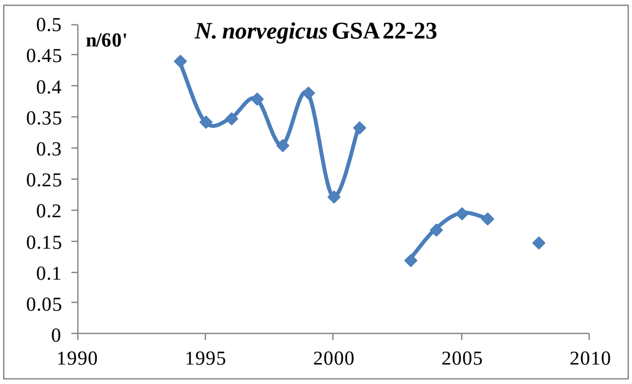



**Fig. 1.8.3.2. Biomass indices of *Nephrops norvegicus* in GSA 22&23 from MEDITS surveys.**

***Trends in abundance by length or age***

***Trends in growth***

***Trends in maturity***

1.8.4 *Assessment of historic stock parameters*

The assessment of Norway lobster from GSA22&23 was performed using length cohort analysis, surplus production models and survey based assessment.

1.8.4.1 Method 1: LCA (DCR data)

***Justification***

Assessment was performed using an LCA (VIT software, Lleonart and Salat 1997) on an annual pseudocohort for the years 2003, 2004, 2005, 2006 and 2008.

***Input parameters***

Catch at length data in GSA 22&23 were provided according to the 2009 Greek Official EC Data Call. LCA was performed using VIT software on data of the years 2003, 2004, 2005, 2006 and 2008. The parameters were also provided according to the 2009 Greek Official EC Data Call. The M vector was calculated with Prodbiom (Abella et al., 1997), and the maturity ogive was from the Spanish DCF. Tab. 1.8.4.1-2 show respectively the input data and parameters. In 2004, due to problem created by the presence of relatively few catches the class length of 10 mm, the first three classes (namely: 10 mm, 12 mm, and 14 mm) has been excluded from the analysis. The terminal F has been assumed as the same of the natural mortality of the older ages.

| | 2003 | 2004 | 2005 | | 2006 | 2008 | |
|---|---|---|---|---|---|---|---|
| Carapace (mm) | Bottom trawls | Bottom trawls | Bottom trawls | Traps | Bottom trawls | Bottom trawls | Traps |
| 10 | 0 | 7787891 | 0 | 0 | 0 | 0 | 0 |
| 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 0 | 20722536 | 32262734 | 0 | 20464040 | 0 | 0 |
| 18 | 10641554 | 32224840 | 125969486 | 0 | 126348011 | 67249200 | 0 |
| 20 | 149096491 | 54232909 | 295086688 | 0 | 692353812 | 0 | 0 |
| 22 | 601157107 | 196253479 | 356844004 | 0 | 1945149931 | 356489559 | 0 |
| 24 | 1083043384 | 688085893 | 904036410 | 0 | 2421876781 | 1510552183 | 0 |
| 26 | 1522647144 | 1208132674 | 1594111946 | 86863625 | 3046017562 | 2833974088 | 0 |
| 28 | 1789064998 | 1906954419 | 1663367992 | 0 | 3367776865 | 4503849545 | 0 |
| 30 | 2662066724 | 1914132751 | 1929203171 | 130295438 | 2805854331 | 4448941896 | 0 |
| 32 | 2635640037 | 1885779011 | 2198256802 | 43431813 | 2521163217 | 3955453685 | 0 |
| 34 | 2556410113 | 1855825146 | 2261530443 | 260590875 | 2410278150 | 3266747846 | 318052174 |
| 36 | 1664898443 | 1044731769 | 1749434975 | 738340813 | 2190937521 | 2115936739 | 583095652 |
| 38 | 1229742268 | 819127125 | 1505384737 | 564613563 | 1596339274 | 1864184648 | 450573913 |
| 40 | 778074618 | 796386938 | 1138726046 | 738340813 | 1332542888 | 1552425033 | 583095652 |
| 42 | 556500088 | 567731796 | 704238858 | 521181750 | 975418977 | 1143436884 | 424069565 |
| 44 | 237138738 | 420260328 | 528862151 | 390886313 | 1016125471 | 1358592433 | 265043478 |
| 46 | 249916771 | 303432450 | 401957711 | 130295438 | 567328063 | 907533859 | 26504348 |
| 48 | 117581572 | 279543412 | 183547397 | 217159063 | 460667442 | 624535470 | 0 |
| 50 | 119843185 | 219843048 | 214184664 | 130295438 | 452175766 | 502640623 | 0 |
| 52 | 41114643 | 155145157 | 173705821 | 0 | 295338796 | 374681169 | 0 |
| 54 | 83902437 | 99856945 | 120562051 | 173727250 | 137078925 | 88354131 | 0 |
| 56 | 68349979 | 77563038 | 70653213 | 130295438 | 113066038 | 112939843 | 0 |
| 58 | 26290629 | 42989549 | 56349954 | 0 | 91292287 | 75117889 | 0 |
| 60 | 11036349 | 15417558 | 22935248 | 0 | 55229306 | 6967711 | 0 |
| 62 | 13541550 | 18120410 | 8827201 | 0 | 43566228 | 0 | 0 |
| 64 | 0 | 16078601 | 9489868 | 86863625 | 21552198 | 7299982 | 0 |
| 66 | 0 | 8385934 | 3569891 | 0 | 19972951 | 0 | 0 |
| 68 | 0 | 0 | 0 | 0 | 0 | 7299982 | 0 |

**Table 1.8.4.1. Input data for LCA of the Norway lobster in GSA 22&23.**

**Table 1.8.4.2. Input parameters for LCA of the Norway lobster in GSA 22&23.**

| **Carapace (mm)** | **Maturity** | **M** | | **Linf** | 78.050 |
|---|---|---|---|---|---|
| 10 | 0.02 | 0.85 | | **k** | 0.131 |
| 12 | 0.02 | 0.85 | | **t0** | -0.426 |
| 14 | 0.03 | 0.49 | | | |
| 16 | 0.05 | 0.49 | | **a** | 0.00037 |
| 18 | 0.06 | 0.37 | | **b** | 3.158 |
| 20 | 0.09 | 0.37 | | **Fterm** | 0.16 |
| 22 | 0.12 | 0.31 | | | |
| 24 | 0.15 | 0.31 | | | |
| 26 | 0.20 | 0.27 | | | |
| 28 | 0.26 | 0.27 | | | |
| 30 | 0.33 | 0.25 | | | |
| 32 | 0.41 | 0.23 | | | |
| 34 | 0.49 | 0.23 | | | |
| 36 | 0.57 | 0.22 | | | |
| 38 | 0.65 | 0.21 | | | |
| 40 | 0.72 | 0.20 | | | |
| 42 | 0.79 | 0.19 | | | |
| 44 | 0.84 | 0.19 | | | |
| 46 | 0.88 | 0.19 | | | |
| 48 | 0.91 | 0.18 | | | |
| 50 | 0.93 | 0.18 | | | |
| 52 | 0.95 | 0.18 | | | |
| 54 | 0.96 | 0.17 | | | |
| 56 | 0.97 | 0.17 | | | |
| 58 | 0.98 | 0.17 | | | |
| 60 | 0.99 | 0.16 | | | |
| 62 | 0.99 | 0.16 | | | |
| 64 | 0.99 | 0.16 | | | |
| 66 | 1.00 | 0.16 | | | |
| 68 | 1.00 | 0.16 | | | |

***Results***

In the graphs in Figure 1.8.4.1 are presented the main results of the LCA analyses carried out for each year separately. The catches are mainly represented by the age classes 1 to 9 and a similar pattern of fishing mortalities in each year is observed.

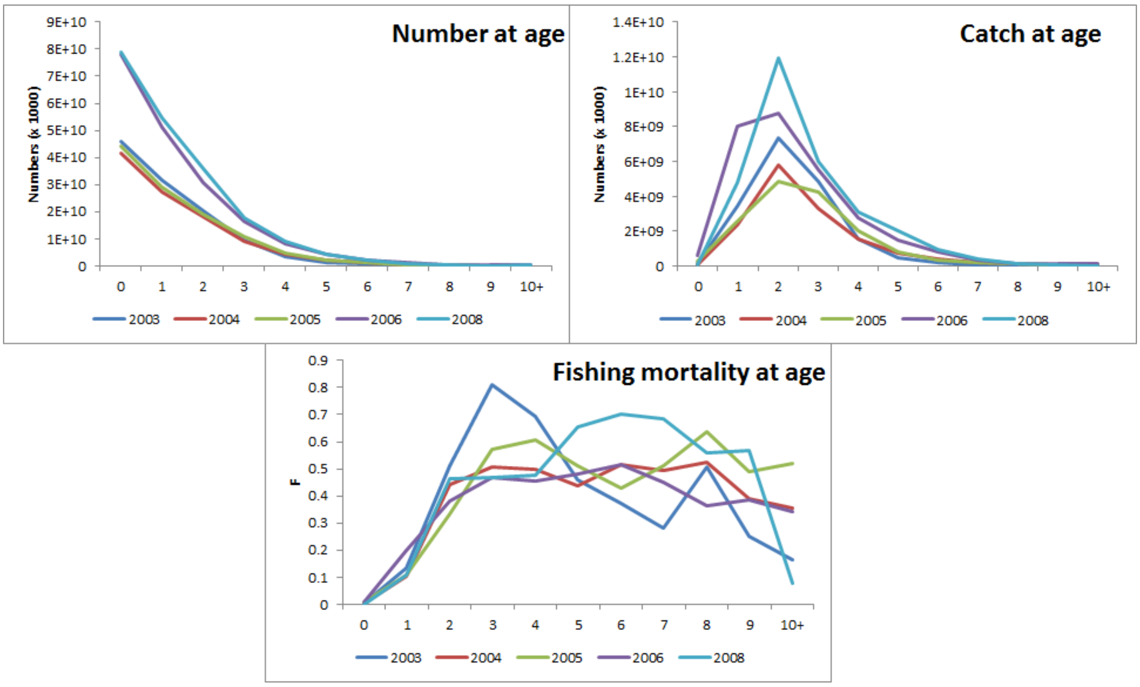



**Fig. 1.8.4.1. LCA outputs. numbers at age, catch at age and fishing mortality at age of *N. norvegicus* in GSA 22&23.**

In the graphs in figure 1.8.4.2 are summarized the amount of the recruitment, the spawning stock biomass, the mean fishing mortalities and the mean fishing mortalities calculated for the most important ages in the catches

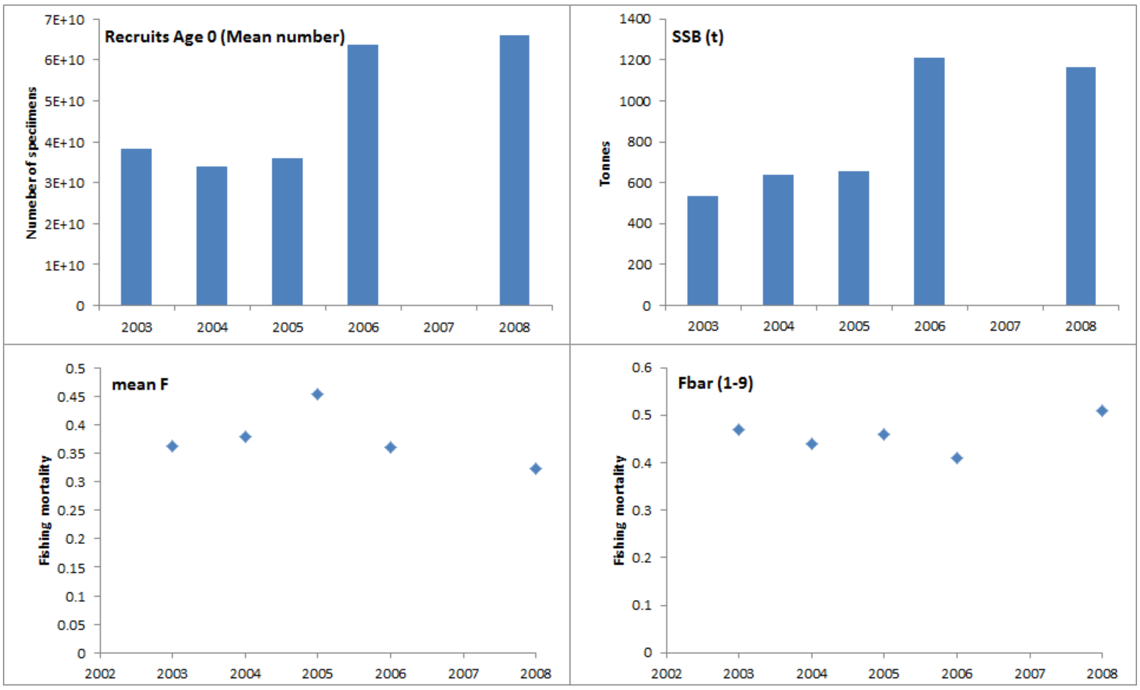



**Fig. 1.8.4.2. LCA outputs: numbers of recruits (Age 0), SSB, meanF and Fbar$_{(1\text{-}9)}$ of *N. norvegicus* in GSA 22&23.**

The results of the yield per recruit analyses are summarized in the graphs in Figure 1.8.4.3 and in Table 1.8.4.3. In all the years the mean F (F= 0.32) is above the $F_{0.1}$ (0.13; average of $F_{01}$ estimated for 2003, 2004, 2006 and 2008), thus the stock is exploited unsustainably. Moreover in 2005 and 2008 the fishing mortality is mainly due to the OTB.

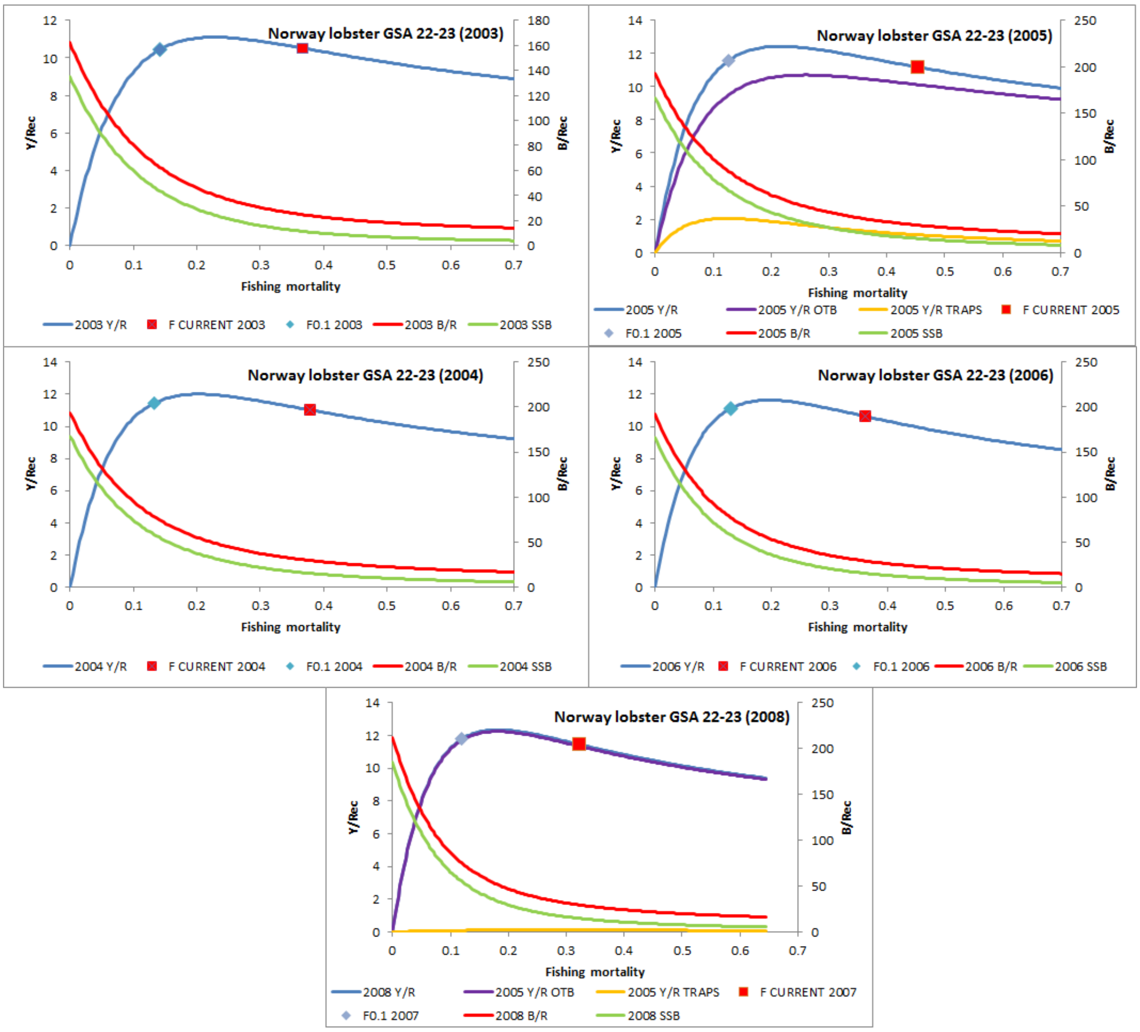



**Fig. 1.8.4.3. YPR outputs. Yield per recruit, B per recruit and SSB per recruit curves for *N. norvegicus* in GSA 22&23. Current F (as mean F) and $F_{0.1}$ are also showed.**

**Table 1.8.4.3. Results of the YPR analysis.**

| **2003** | **Factor** | **F** | **Y/R** | **B/R** | **SSB** |
|---|---|---|---|---|---|
| **F(0)** | 0 | 0 | 0 | 161.93 | 135.00 |
| **F(0.1)** | 0.41 | 0.15 | 10.58 | 60.05 | 41.51 |
| **FMax** | 0.64 | 0.23 | 11.10 | 40.29 | 24.23 |
| **phi=1** | 1.01 | 0.37 | 10.54 | 24.97 | 11.59 |
| **phi=2** | 2 | 0.73 | 8.80 | 13.69 | 3.77 |
| **2004** | **Factor** | **F** | **Y/R** | **B/R** | **SSB** |
| **F(0)** | 0 | 0 | 0 | 193.86 | 167.85 |
| **F(0.1)** | 0.35 | 0.13 | 11.45 | 78.36 | 58.56 |
| **FMax** | 0.54 | 0.20 | 12.01 | 55.35 | 37.59 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **phi=1** | 1.01 | 0.38 | 11.02 | 29.68 | 15.45 | | |
| **phi=2** | 2 | 0.76 | 9.01 | 15.77 | 5.20 | | |

| **2005** | **Factor** | **F** | **Y/R** | **B/R** | **SSB** | **Y/R $_{OTB}$** | **Y/R $_{TRAP}$** |
|---|---|---|---|---|---|---|---|
| **F(0)** | 0 | 0 | 0 | 192.31 | 166.32 | 0 | 0 |
| **F Max TRAP** | 0.28 | 0.13 | 11.46 | 89.40 | 68.48 | 9.40 | 2.05 |
| **F(0.1)** | 0.3 | 0.14 | 11.78 | 83.35 | 62.85 | 9.73 | 2.05 |
| **F Max** | 0.49 | 0.22 | 12.43 | 57.80 | 39.43 | 10.63 | 1.80 |
| **F Max OTB** | 0.58 | 0.26 | 12.34 | 49.63 | 32.14 | 10.70 | 1.64 |
| **phi=1** | 1.01 | 0.46 | 11.18 | 29.35 | 14.87 | 10.12 | 1.06 |
| **phi=2** | 2 | | 9.18 | 16.33 | 5.41 | 8.68 | 0.51 |

| **2006** | **Factor** | **F** | **Y/R** | **B/R** | **SSB** |
|---|---|---|---|---|---|
| **F(0)** | 0 | 0 | 0 | 192.31 | 166.32 |
| **F(0.1)** | 0.36 | 0.13 | 11.11 | 77.50 | 58.05 |
| **FMax** | 0.55 | 0.20 | 11.63 | 54.82 | 37.50 |
| **phi=1** | 1.01 | 0.36 | 10.63 | 29.23 | 15.55 |
| **phi=2** | 2 | 0.72 | 8.46 | 14.58 | 4.90 |

| **2008** | **Factor** | **F** | **Y/R** | **B/R** | **SSB** | **Y/R $_{OTB}$** | **Y/R $_{TRAP}$** |
|---|---|---|---|---|---|---|---|
| **F(0)** | 0 | 0 | 0 | 211.87 | 184.71 | 0 | 0 |
| **F(0.1)** | 0.37 | 0.12 | 11.78 | 75.46 | 55.26 | 11.69 | 0.09 |
| **F Max TRAP** | 0.57 | 0.18 | 12.35 | 51.89 | 33.85 | 12.24 | 0.11 |
| **Fmax** | 0.57 | 0.18 | 12.35 | 51.89 | 33.85 | 12.24 | 0.11 |
| **F Max OTB** | 0.85 | 0.27 | 11.89 | 34.85 | 19.12 | 11.77 | 0.12 |
| **phi=1** | 1.01 | 0.33 | 11.46 | 29.47 | 14.74 | 11.35 | 0.11 |
| **phi=2** | 2 | | 9.40 | 16.23 | 5.29 | 9.33 | 0.08 |

#### 1.8.4.2 Method 2: Method 1: Stock Production Model

***Justification***

A production model has been employed in order to estimate the fishing mortality and the biomass at sea and the relative reference points in term of $F_{MSY}$ and $B_{MSY}$, using the catch and effort data estimated as in Section 1 of this report and by Moutoupolous and Stergiou (2012).

***Input parameters***

A non-equilibrium dynamic biomass model incorporating covariates [ASPIC 5.10.1] (Prager 2005) was applied to catch and effort (hP x Days) data from the GSAs 22 and 23. It is important to notice that the data shown in Fig. 1.8.4.4 were derived from the landings reported through the DCF, whereas ASPIC model uses the reconstructed data as described Section 1 of this report. The logistic model was used. In addition to data on catch and effort, ASPIC requires starting guesses and ranges for the parameters to be estimated by the model: carring capacity (K), maximum sustainable yield (MSY), the ratio of the biomass at the beginning of the first year to the carrying capacity (B1/K) and catchability (q) (Table 1.8.4.4).

**Table 1.8.4.4. ASPIC input parameters of the FIT mode for GSA 22 & 23.**

| B1/K | MSY | Range of MSY | K | Range of K | Fishing fleet | q (mean (CPUE) / 2*max(Y)) |
|---|---|---|---|---|---|---|
| 1.331 | 2.75E+02 | 8.0E+01 - 6.0E+02 | 1.42 E+03 | 8.0E+02 - 8.0E+03 | Small scale | 6.29 E-09 |

After fitting the values for the above parameters, the FIT mode is run. At this point ASPIC computes estimates of parameters, including time trajectories of fishing intensity and stock biomass. The results of the fit were used to compute bias-corrected approximate confidence limits (80% CL) through bootstrap analysis. The model fittings are under the assumption that yield in each year is known more precisely than fishing effort or relative abundance from MEDITS survey, which has been discarded from the model because did not provide a better fit. In other words, all model fittings were conditioned on yield, rather than on effort or relative abundance (Prager 2005).

If there is normal convergence, the point estimates of the FIT mode were loaded in the BOT mode for bootstrapping. In this mode the programme computes bootstrap confidence intervals on estimated quantities. This approach resamples the residuals from the optimum fit to generate new bootstrap samples of the observed time series. The residuals between the observed and predicted catch rates (CPUE), are used for bootstrap analysis. Bootstrap data sets are constructed by combining predicted CPUE with a randomly chosen residual to compute a pseudo-CPUE value. The model is then refit, using the pseudo-CPUE, which is assumed to relate back to stock biomass via the catchability coefficient (CPUE = qBt). The process is repeated at least 1000 times (bootstrap trials) for each different fit. At each trial the objective function used is the sum of squared errors (Haddon 2001, Prager 2005).

***Results***

Initial runs in the ASPIC FIT mode and the observed CPUE and predicted CPUE indexes are shown in Figure 1.8.4.5. A clear decreasing trend in CPUEs is observed for all the runs.

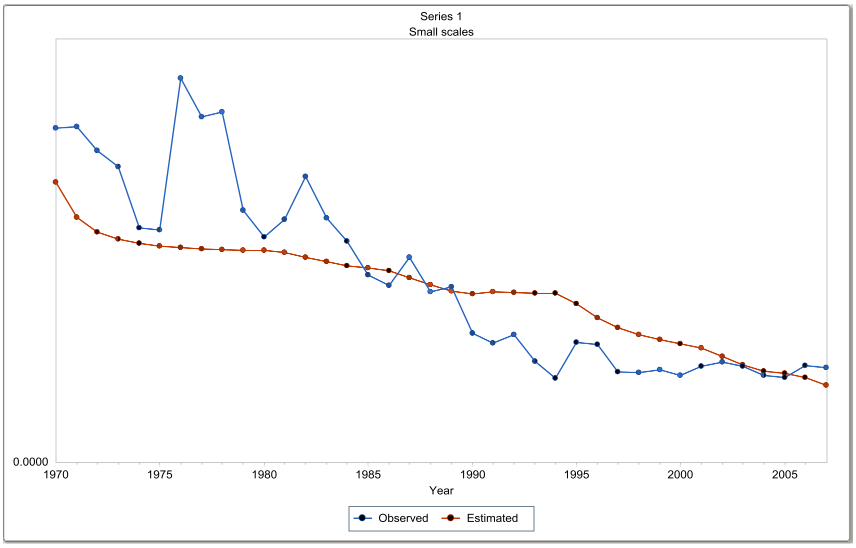



**Fig.1.8.4.5. Observed and predicted values of CPUE of *N. norvegicus* in GSA 22&23 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1970-2007.**

In the logistic model the estimated biomass and fishing mortality fluctuated respectively from 1700 to 450 t and 0.05 and 0.62 (Figure 1.8.4.6). The biomass was estimated to be lowest since 1970, while the F reached highest values from 1995 to 2007.

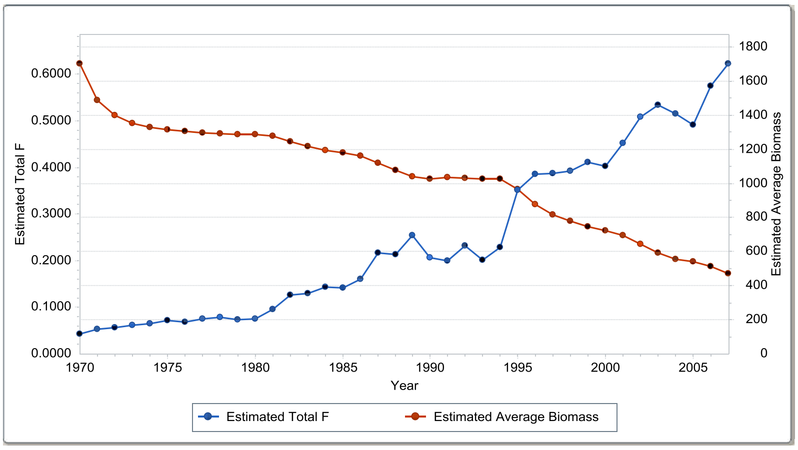



**Fig.1.8.4.6. Estimated average biomass and fishing mortality of *N. norvegicus* in GSA 22&23 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1970-2007.**

The goodness of fit of each model is presented in Table 1.8.4.5. The logistic model presented a general good fit also in terms of contrast and nearness.

**Table 1.8.4.5. Goodness of fit results for the logistic model in ASPIC.**

| Loss component number and title | Weighted SSE | N | Weighted MSE | Current weight | In. var. weight | R-squared CPUE |
|---|---|---|---|---|---|---|
| Loss(-1) SSE in yield | 0.00E+00 | | | | | |
| Loss(0) Penalty for B1 > K | 8.189E-02 | 1 | | 1.00E+00 | | |
| Loss(1) Small scales | 3.066E+00 | 38 | 8.516E-02 | 1.00E+00 | 1.00E+00 | 0.611 |
| TOTAL OBJECTIVE FUNCTION, MSE, RMSE: | 3.148E+00 | | 8.993E-02 | 2.999E-01 | | |
| Estimated contrast index (ideal = 1.0): | 1.0182 | | C* = (Bmax-Bmin)/K | | | |
| Estimated nearness index (ideal = 1.0): | 1.000 | | N* = 1 - \|min(B-Bmsy)\|/K | | | |

The estimates of MSY, $B_{MSY}$, $F_{MSY}$, $f_{MSY}$ for GTR are shown in Table 1.8.4.6 and the estimates of MSY and $F_{MSY}$ ranges after bootstrapping using approximate 80% upper and lower confidence limits are shown in Table 1.8.4.7.

**Table 1.8.4.6. Estimated parameters of Nephrops in GSA 22 & 23.**

| Model | MSY (tons) | $B_{MSY}$ (tons) | $F_{MSY}$ | B(2008)/Bmsy | F(2007)/Fmsy | $f_{MSY}$ Small scale |
|---|---|---|---|---|---|---|
| Logistic | 2.747E+02 | 7.120E+02 | 3.858E-01 | 6.261E-01 | 1.613E+00 | 6.135E+07 |

**Table 1.8.4.7. Estimates of MSY and $F_{MSY}$ from bootstrapped analysis in ASPIC with confidence limits.**

| Model | | MSY | | | $F_{MSY}$ | |
|---|---|---|---|---|---|---|
| | 80% lower | | 80% higher | 80% lower | | 80% higher |
| Logistic | 2.705E+02 | 2.747E+02 | 2.831E+02 | 3.596E-01 | 3.858E-01 | 4.481E-01 |

The relative biomass ($B/B_{MSY}$) and fishing mortality ($F/F_{MSY}$) are showed in Figure 1.8.4.7 for the logistic model.

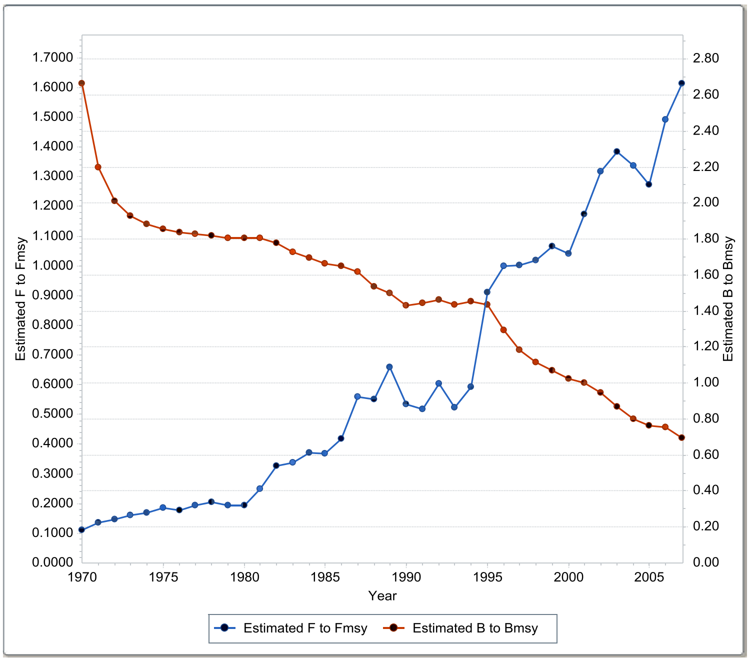



**Fig.1.8.4.7. Historic trend in estimated fishing mortality as $F/F_{MSY}$ ratio and biomass as $B/B_{MSY}$ ratio from Logistic model.**

The results of the production models suggest that Norway lobster in the GSA 22&23 is exploited unsustainably, considering that the current F is 1.61 times above the $F_{MSY}$ ($F/F_{MSY}$ =1.61). The biomass at sea, after five decades of higher exploitation, is below the $B_{msy}$, with the current biomass being 63% of $B_{MSY}$ ($B/B_{MSY}$ = 0.63).

### 1.8.4.3 Method 3: SURBA (Survey Based Assessment)

***Justification***

The relatively long time series of data available from the MEDITS surveys provided the most useful data set to analyse the trend of *Nephrops norvegicus* stock in GSAs 22&23. The MEDITS indices of abundance (n/hour) for Norway lobster in GSA 22&23, covering the period 1994-2008 were analysed using SURBA (Survey Based stock Assessment approach, Needle, 2003). The annual standardized size distributions (1 mm carapace length class) from MEDITS were converted in age distributions using the statistical slicing method approach developed during STECF EWG 11-14 (Scott *et al.*, 2011). In each year a single age distribution was obtained for the two sexes combined.

The slicing was carried out using both the classical knife edge approach and by fitting different distributions (normal, lognormal, gamma) over the LFD data (Fig. 1.8.4.8).

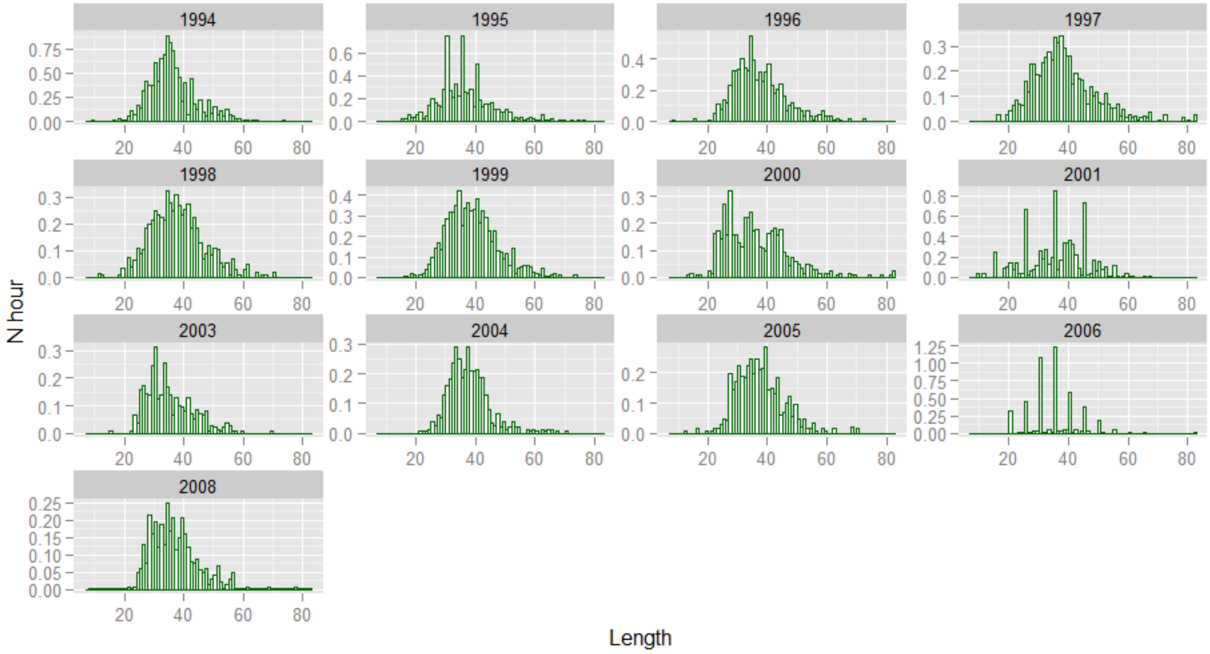
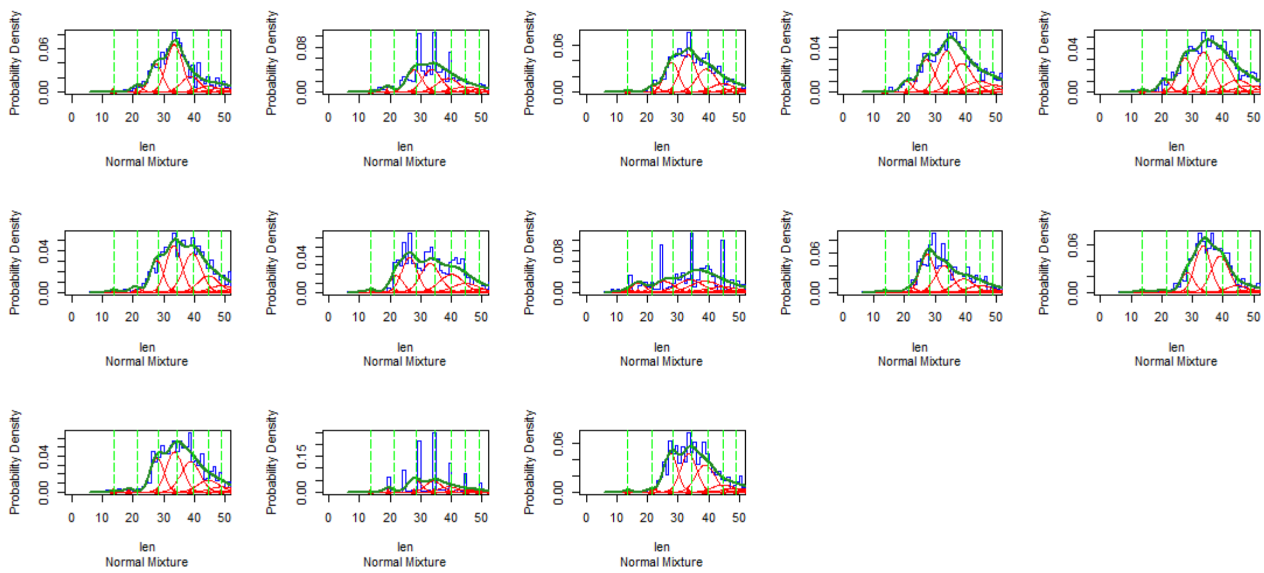
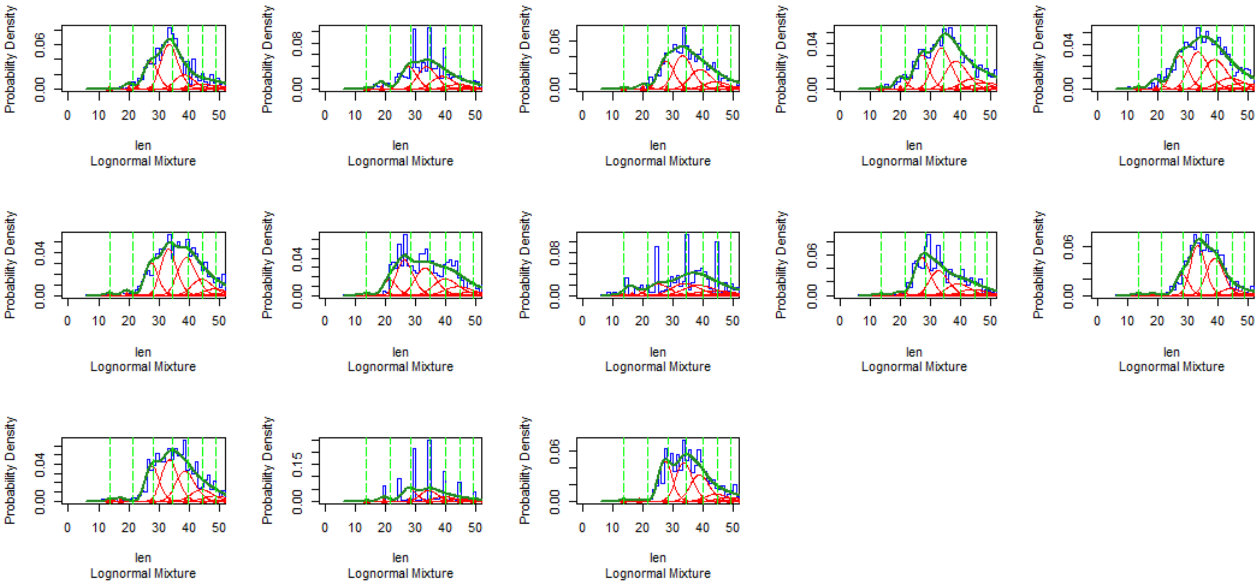



**Fig. 1.8.1.8. MEDITS length frequency distributions of Norway lobster in the GSA 22-23.**

*Normal*




*Lognormal*




*Gamma distribution*

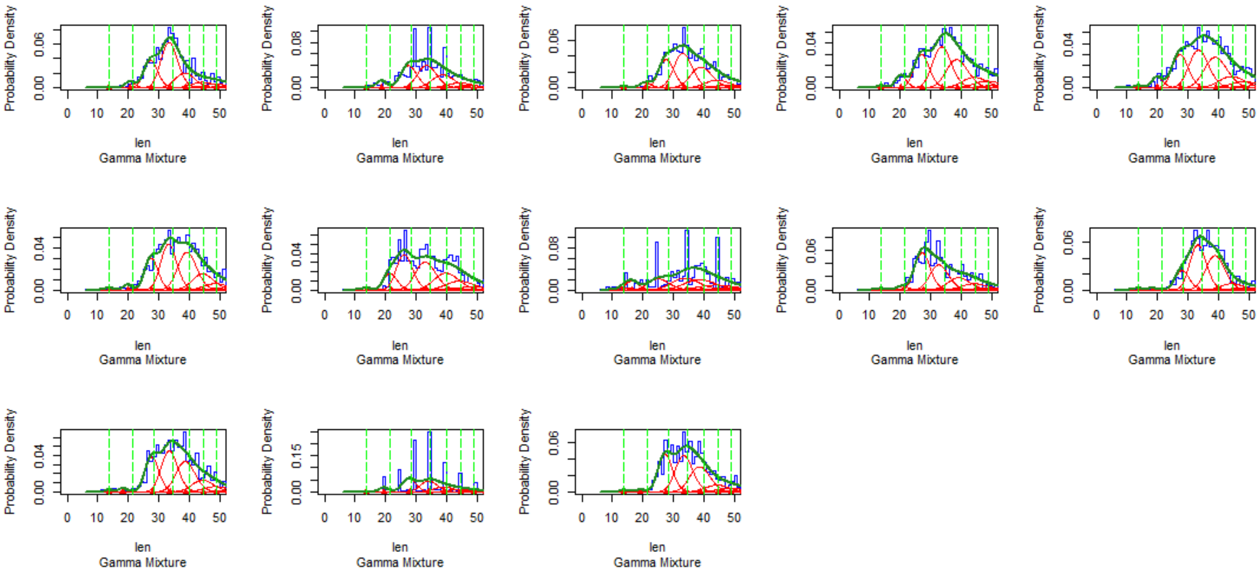



**Fig. 1.8.4.9. Result of fitting normal, lognormal and gamma distribution to 1994-2008 LFD data for Norway lobster in GSA 22-23. The red triangles on the x-axis indicate the position of mean of each distribution. The green vertical lines indicate where the von Bertalanffy growth curve places each age group. For the last three ages this coincides with the mean of the distribution because that is how we set our constraints.**

The value of chi-squared ($\chi^2$) and the degrees of freedom (df) were calculated for each distribution to compare the fits by calculating the reduced $\chi^2_{red}$, where $\chi^2_{red} = \chi^2$ /df (see Table 1.8.4.8 and Fig. 1.8.1.13). The adopted role of thumb is that the larger the $\chi^2_{red}$, the worse the fit. Since the better fit does not imply that the resulting estimates of mean-length-at –age are biological consistent, the final choice of the distribution depends also by the final judgement of the scientist. To this aim we have considered the reliability of the length-at age estimated by the three distributions and the consistence of the resulting cohorts.

**Table 1.8.4.8. Reduced chi-squared ($\chi^2_{red} = \chi^2/df$ )values from fitting with the three distributions.**

| | normal | lnorm | gamma |
|---|---|---|---|
| 1994 | 0.03 | 0.03 | 0.03 |
| 1995 | 0.04 | 0.04 | 0.04 |
| 1996 | 0.02 | 0.02 | 0.02 |
| 1997 | 0.02 | 0.02 | 0.02 |
| 1998 | 0.01 | 0.01 | 0.01 |
| 1999 | 0.01 | 0.01 | 0.01 |
| 2000 | 0.02 | 0.02 | 0.02 |
| 2001 | 0.10 | 0.11 | 0.11 |
| 2003 | 0.01 | 0.01 | 0.01 |
| 2004 | 0.01 | 0.01 | 0.01 |
| 2005 | 0.01 | 0.01 | 0.01 |
| 2006 | 0.22 | 0.22 | 0.21 |
| 2008 | 0.01 | 0.01 | 0.01 |

After checking the estimated mean length at age and the fitting of the SURBA model over the different numbers-at-age matrices obtained from the statistical slicing, we decided to adopt the data matrix calculated with the knife edge slicing (Fig. 1.8.4.10). Once removed the first age classes (0-3), this was the only age data matrix returning a rather consistent SURBA model pattern with in terms of model fitting.

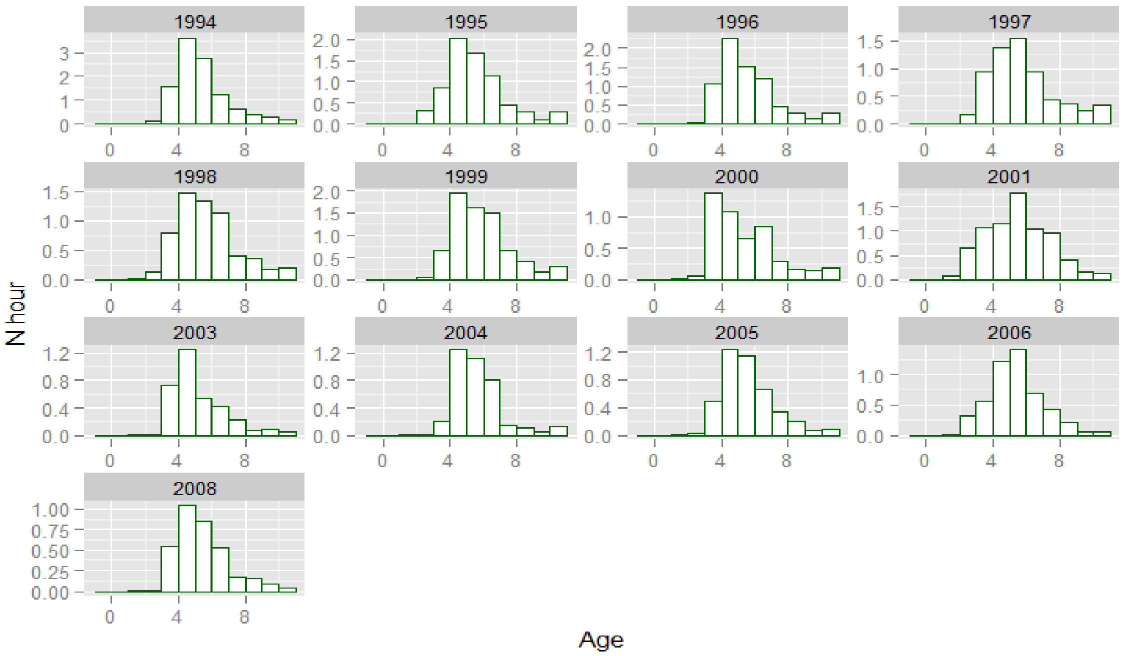



**Fig. 1.8.4.10. Numbers at age distributions of Norway lobster for MEDITS 1994-2008 in GSA 22&23 obtained by knife edge slicing.**

***Input parameters***

Table 1.8.4.10 shows the input parameters used to run SURBA. The age groups 0-3 were removed from the dataset because they were poorly captured by the MEDITS.

Single survey exploratory SURBA model runs were carried out fitting constant catchability (1.0 for all ages).
The model settings are given below:

Year range: 1994-2008, 2002 and 2007 lacking
Age range: $4\text{-}11^{+}$
Age weighting: 1.0 (ages 4-8), 0.80 (ages 9-10), 0.70 (age 11+)
Smoothing Index Rho: 2.0
Cohort weighting: not applied

**Table 1.8.4.10. Input parameters of SURBA.**

**Growth parameters**

| Sex | L∞ | k | t0 | a | b |
|---|---|---|---|---|---|
| F+M | 78.05 | 0.131 | -0.426 | 0.000000373 | 3.1576 |

**Proportion of mature**

| Age | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11+ |
| 0.90 | 0.95 | 0.97 | 0.98 | 1 | 1 | 1 | 1 |

**Natural mortality**

| Age | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11+ |
| 0.22 | 0.21 | 0.20 | 0.18 | 0.17 | 0.14 | 0.13 | 0.12 |

***Results***

Comparative scatterplots at age indicated a poor consistency of the MEDITS data, between age 5 against age 6 the year after (Fig. 1.8.4.11)

The trends in $F_{4\text{-}9}$, SSB and recruitment at age 0 from SURBA run, and the model residuals are given in Figures 1.8.4.12-13. The retrospectives for the MEDITS survey data are given in Figure 1.8.1.18.

The estimates can be considered reliable since 1997 when the sampling effort increased from 85-105 to 135-149 stations sampled.

SURBA estimated an increasing trend in the temporal effect (f) with large fluctuations in 2004-2008. The model estimates large fluctuations in the temporal effect with an increase since 2000. The age effect showed an increase from age 5 to age 11 plus, with some inconsistencies for age 9. The cohort effect indicated a decline in the recruitment through.

An increase total mortality (Z) was estimated from 1997 (0.45) to 2007 (1.0). $F_{4\text{-}8}$(bootstrapped estimates) increased from 0.27 (1997) and 0.78 (2007), ranging between 0.56-0.78 in 2005-07. The estimated relative SSB showed a continuous decreasing temporal trend.

The residuals at age did not show any major pattern, except for age 10. The retrospective showed large uncertainty in the estimation of the age effect.

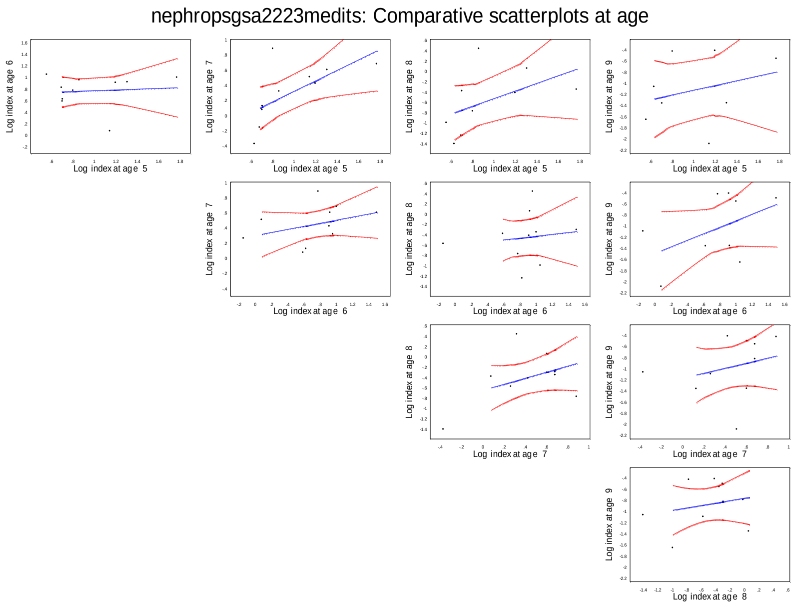
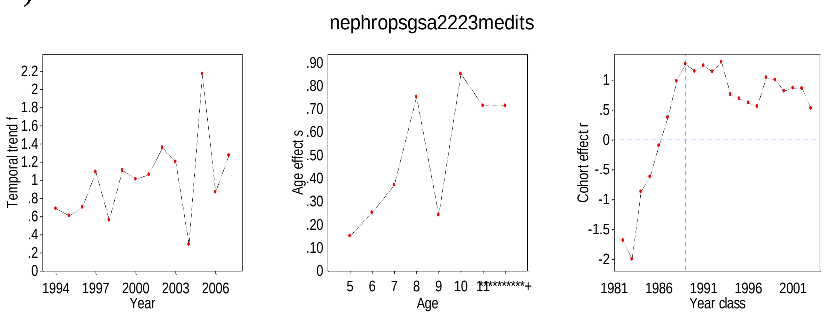
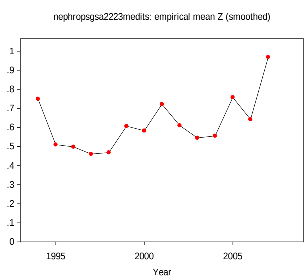



**Fig. 1.8.4.11. Norway lobster in GSAs 20: Output from SURBA plots for MEDITS survey (ages 1-5), showing age scatter plots.**

A)




B)




C)

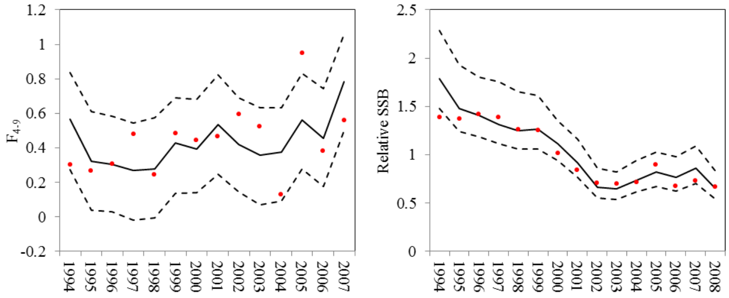
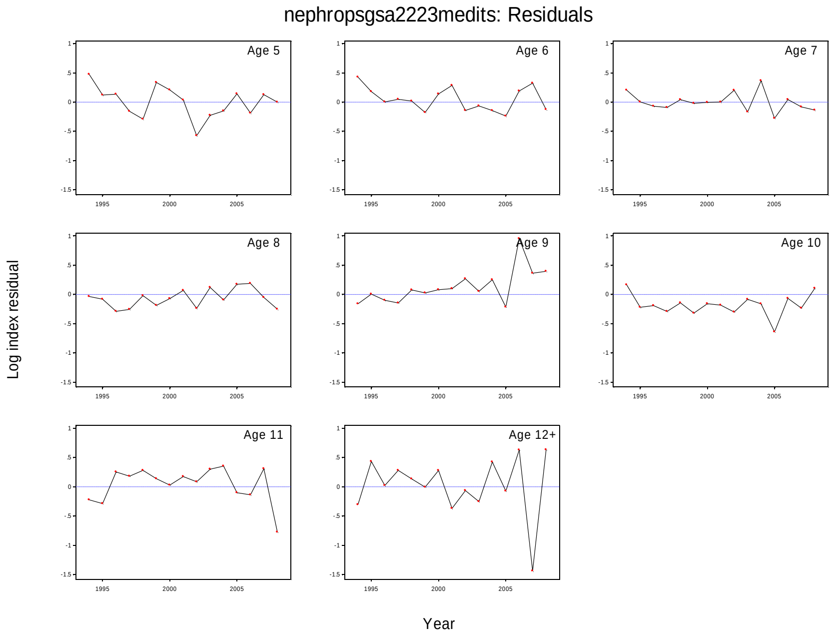



**Fig. 1.8.4.12. SURBA estimates for Norway lobster in GSAs 22&23. A) model parameters. B) total mortality ($Z_{4\text{-}9}$) C) bootstrapped (lines) and fitted (points) estimates of $F_{4\text{-}8}$ and SSB, , solid and dotted lines are respectively 50% and 5- 95% of bootstrapped estimates.**

A)




B)

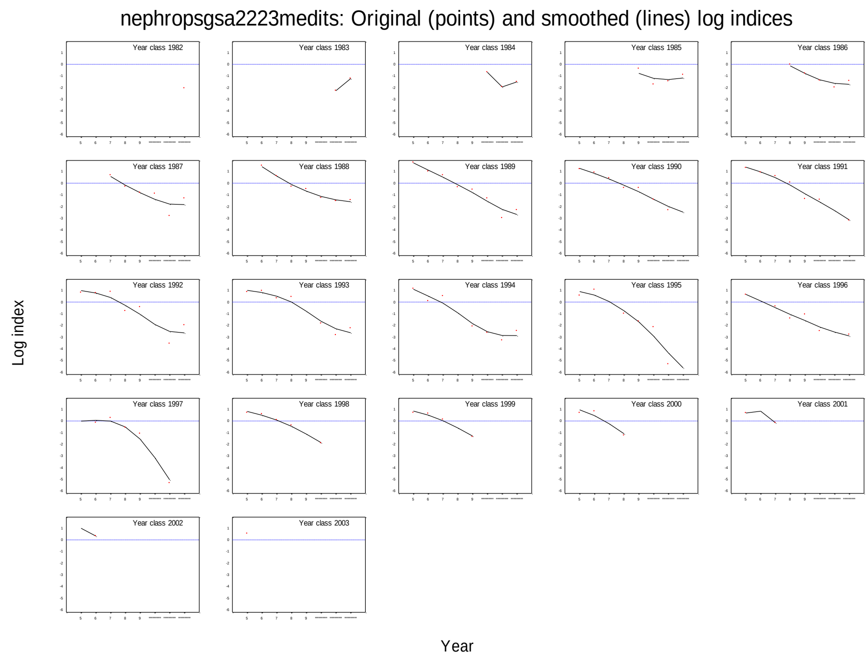



**Fig. 1.8.4.13. SURBA model diagnostic for Norway lobster in GSAs 22&23. A) Temporal trend in residuals by age B) Observed (points) and fitted (lines) year classes.**

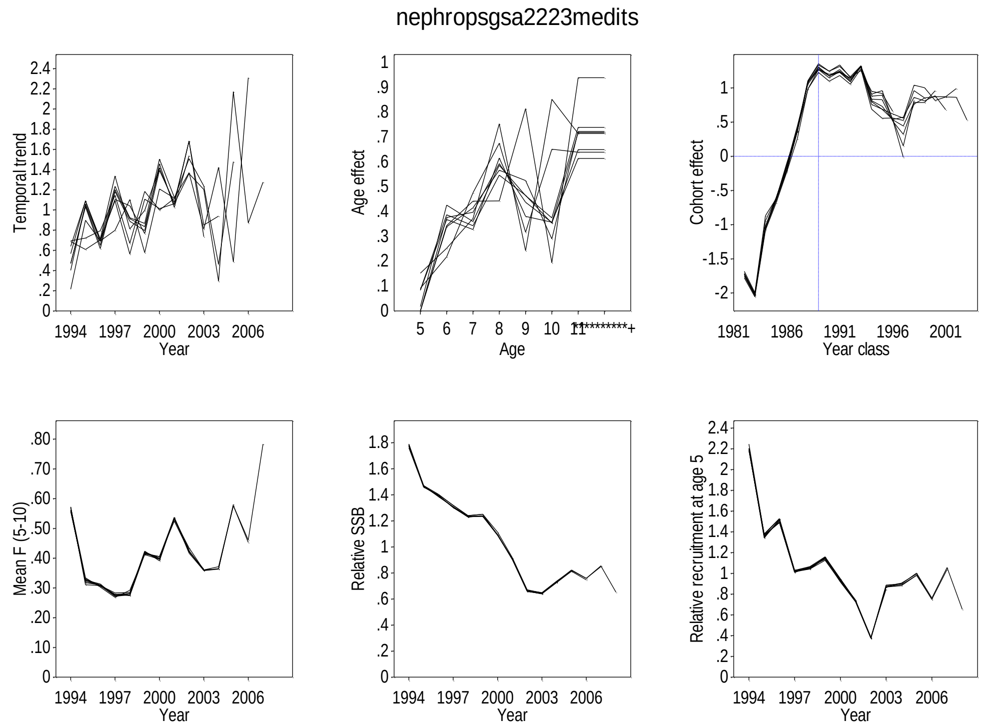



**Fig. 1.8.4.14. SURBA model of Norway lobster in GSAs 22&23: retrospective analysis.**

## 1.8.5 *Scientific advice*

LCA did not show any clear trend in F, SSB or R but showed that a reduction of 60-70% of fishing mortality should be applied to reach the estimated proxy of Fmsy (i.e. $F_{01}$). Production models showed under-exploitation before the period 1998-2000 and over-exploitation after then. SURBA analysis showed a clear decreasing trend in the SSB and a slight increase in F.

***State of the spawning stock size***

In the absence of proposed or agreed precautionary reference is not possible to fully evaluate the status of the spawning stock size. SURBA results show a decline in SSB from 1998 to 2008 while LCA shows an increase from 2006 to 2008.
The total biomass at sea in 2008 estimated with the production model using the logistic approach, is, about 60% of $B_{MSY}$ ($B/B_{MSY}$ = 0.62).

***State of recruitment***

SURBA results show a decline in recruitment since 1998 while LCA shows an increase from 2006 to 2008.

***State of exploitation***

The values of current F estimated by ASPIC with the logistic model ($F/F_{MSY}$ = 1.61) suggests that Norway lobster in GSA 22&23 is exploited unsustainably. SURBA results show a continous increase in F in the last decade. LCA shows a stable F trend around 0.32, about 3 times higher than the estimated $F_{MSY}$ (0.12).

Based on all the results, Norway lobster in GSA 22&23 can be considered exploited unsustainably.

#### 1.8.5.1 Data quality

DCR data: although according to landings, nets are the second most important gear in catches after trawl, length frequency distributions were only provided for trawling and traps. According to bibliography, the second most important gear exploiting this species is traps, so landing information from nets is probably erroneous. Length frequency distributions from traps are only available for 2005 and 2008, which could affect the results.

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Prager, M.H. 2005. User’s Manual for ASPIC: Stock Production Model Incorporating Covariates (ver. 5) and Auxiliary Programs. National Marine Fisheries Service. Population Dynamic Team. CCFHR/NOCAA-North Carolina, USA

## 1.9 Stock assessment of red mullet *Mullus barbatus* GSA 20

### 1.9.1 *Stock identification and biological features*

#### 1.9.1.1 Stock Identification

Red mullet is distributed along the shelf of all the Mediterranean countries. The species can be found at depths over 200m, but is mainly concentrated in the depth range 0-100m. All the year classes and nursery and spawning areas are well distributed along the narrow Mediterranean shelves. There is not a definition of unit stocks in the area. Thus, the analysis assumed that red mullet in GSA20 is a single stock unit.

#### 1.9.1.2 Growth and Natural Mortality

*Mullus barbatus* is a fast growing species. The following growth parameters considered representative for *M. barbatus* in GSA 20 were utilized in the successive analyses (taken from STECF12-10 (Sète, July 2012) report, and used for *M. barbatus* in GSA 18).

Growth parameters: $L_\infty$= 30 cm; K=0.4; a=0083; b=3.1134

An M vector derived from ProdBiom (Abella, Caddy & Serena, 1997) was used:

Natural mortality (M) as estimated with ProdBiom:

| M | | | |
|---|---|---|---|
| Age 0 | age 1 | age 2 | age 3+ |
| 1.00 | 0.61 | 0.54 | 0.5 |

#### 1.9.1.3 Maturity

The species reaches massively the sexual maturity at one year old. Observations of proportion of mature individuals by size and analysis with the standard procedure have produced the following sizes at age maturity by sex.

**Proportion of mature**

| Age | | | |
|---|---|---|---|
| 0 | 1 | 2 | 3+ |
| 0.16 | 0.92 | 1 | 1 |

### 1.9.2 *Fisheries*

#### 1.9.2.1 General description of fisheries

*Mullus barbatus* is among the most commercially valuable species in the areas and is an important component of a species assemblage that is the target of the bottom trawling fleets and small scale

fisheries operating near shore. The small mesh size of the cod end in all cases defines a very precocious size/age of first capture. The species is mostly caugh by small-scale fisheries using set nets.
On average in the analysed period, the main catches of *Mullus barbatus* proceed in GSA20 from small scale fisheries (64%), while trawlers catches represent about 28% followed by beach seines (6%) and only 2% from purse seiners. In the case of GSA 22 & 23, the proportions are as follows: Trawlers 48%, purse seiners 1%, beach seines 5% and small scale 46%.

The exerted fishing pressure on this species on different GSAs may be quite different because conditioned by the structural composition of the fractions of the fleets that operate close to their respective ports, by the characteristics of the potentially exploitable grounds and also by differences in the fisheries' target choices among fleets and zones. *Mullus barbatus* catch rates are higher during the post-recruitment period (from September to November). The trawlers and the small scale artisanal vessels are the main categories that exploit the species in the estudied areas.

#### 1.9.2.2 Management regulations applicable in 2009 and changes in 2010

From Gozalvo et al. (2011):

- Bottom trawl:
    - Minimum distance from the coast
    - Mesh size dimensions
    - Temporal closure
    - Minimum fishing depth
- Netters:
    - Maximum dimension of nets
    - Minimum mesh size
    - Type of thread

Management regulations applicable in 2007 and 2008

RD 917/1966 is the principal law regulating the operation of trawlers. Although this law is still in effect, it has been superseded by EC Regulation 1626/1994, and its replacement Regulation 1967/2006. The main restrictions established by Greek and European legislation are:

(1) establishment of a total exclusion zone one and a half mile from the coastline of the mainland and the islands,
(2) a total fishing ban from the 1st of June till the end of September,
(3) establishment of a total exclusion zone which is: either a zone three miles from the coastal line or a zone shallower than 50 m,
(4) minimum cod-end mesh size is 40 mm (EC regulation 1967/2006); from 1 July 2008, the net shall be replaced by a square-meshed net of 40 mm at the cod-end or, at the duly justified request of the ship owner, by a diamond meshed net of 50 mm.

Additional restrictions exist for bottom trawling in specific areas: in Amvrakikos Gulf and some parts of the Korinthiakos Gulf and the Ionian Sea, trawling is prohibited all year around, while in Patraikos Gulf trawling is prohibited from the 1st of March till the end of November and in the entire Korinthiakos is prohibited from from the 1st of April till the end of November (Presidential Decree 698/81).

The operation of the bottom set nets is subject to the following main restrictions:
(1) the maximum total length of the trammel net is 6000 m.
(2) the minimum mesh size opening is 16 mm.
(3) monofilament or twine diameter of the net should not exceed 0.5 mm.
(4) the maximum drop of a combined trammel and gill net should not exceed 10 m and the length of combined nets should not exceed 2,500 m.

For the bottom longlines the only restriction derives from ER 1967/2006 and referred to maximum number of hooks per fishers (1000 hooks) and the total maximum number of hooks per vessel (5000 hooks)

1.9.2.3 Catches

***Landings***

Annual landings proceeding from small scale fishing vessels and bottom trawlers dominate the landings. Landings data used in the production model are estimates of landings of red mullet and effort for GSA 22 & 23 provided by Moutoupolous and Stergiou (2012) FAO-FISHSTAT GFCM database.

The annual landings (Figure 1.9.2.1), mostly proceeding from small scale fisheries, ranged in the last 4 years from 933 to 1200 tons in GSA20, and from 2228 to 2798 tons in GSA 22 & 23. Annual landings (t) by fishing technique. Landings size show a very high seasonal variability, with peaks at the end of summer (september) determined by the increase in availability/vulnerability after the massive recruitment on the coastal area.

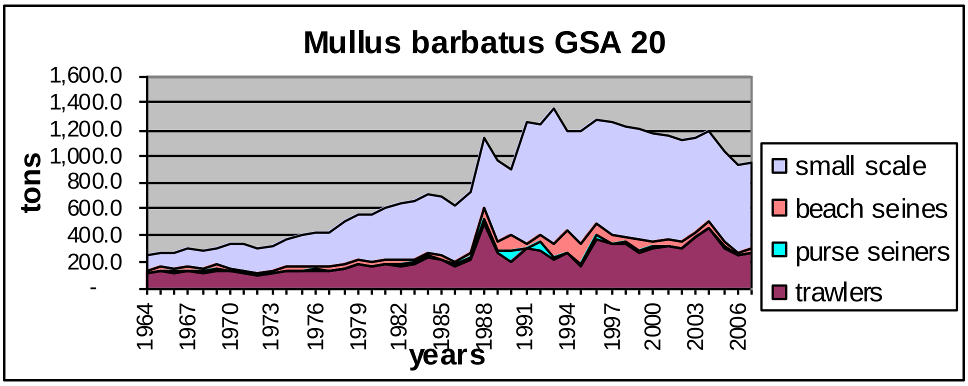
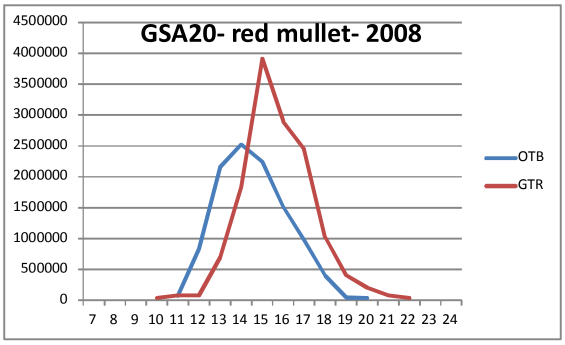



**Fig.1.9.2.1. Landings of *M.barbatus* in GSA 20 for the years 1964-2007.**



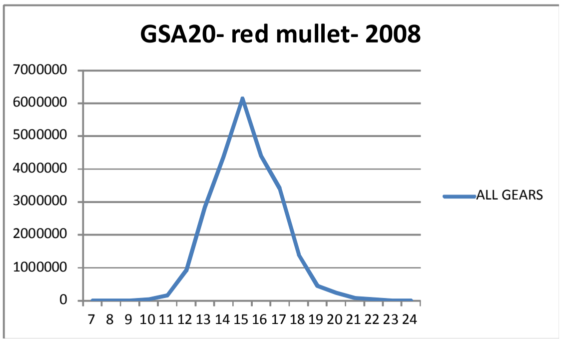




**Fig 1.9.2.2. Age structure of landings for trawlers and artisanal fleet in numbers for year 2008 (DCR data).**

Landings data 2003-2008 from the DCR are not shown because not all fishing gears used were reported (see "data quality and availability").

***Discards***

No data on discards available from the DCR.

***Fishing effort***

The fishing effort for each year was reconstructed using several sources. Effort is expressed here as activity (number of days at sea) x overall HP corrected by a factor that takes into account the increased fishing power due to technological and experience improvements (technological kreeping). A yearly increase in fishing efficiency was estimated to be of 2.72% (see section 1 of this report for details).

### 1.9.3 *Scientific surveys*

#### 1.9.3.1 MEDITS

***Methods***

Based on the DCR data call, abundance and biomass indices were recalculated. Data were assigned to bathymetric strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes trawling duration. Only hauls considered valid were used in the computations. Valid hauls include the cases of null catches of the species.

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = $Yst \pm t$(student distribution) $* V(Yst) / n$

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution and quasi-poisson. Indeed, data may be better modeled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (sub-samples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

***Geographical distribution patterns***

Figure 1.9.2.3 provides the distribution of sampling hauls of the MEDITS survey in GSA 20.

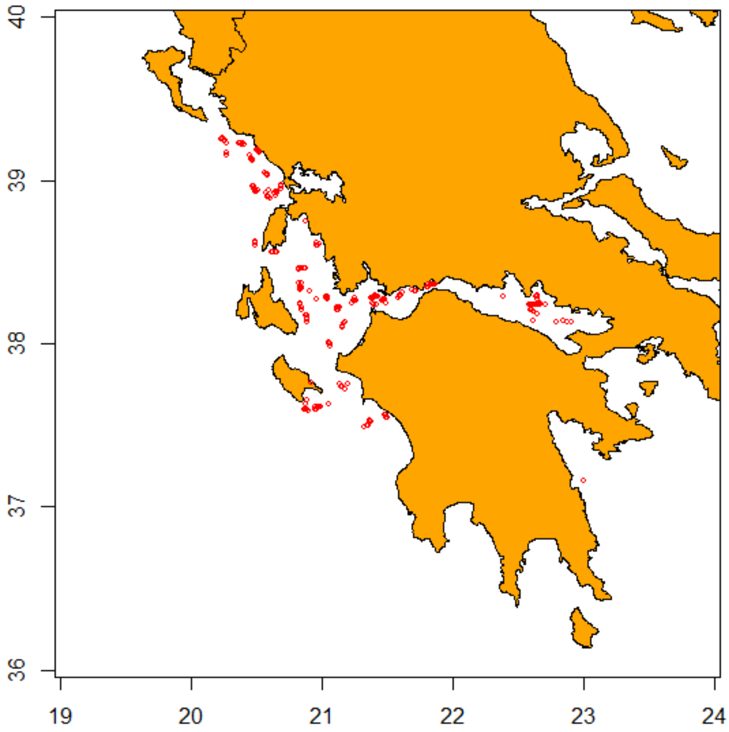



**Fig. 1.9.2.3. Distribution of sampling hauls of the MEDITS survey in GSA 20.**

***Trends in abundance and biomass***

Fishery independent information regarding the state of the red mullet in GSA 09 was derived from the international survey MEDITS. Figure 1.9.2.4 displays the estimated trends in abundance and biomass. The estimated abundance and biomass indices in GSA 20 reveal high fluctuations since 1994 with a mean abundance index of about 50 kg/km$^2$, apparently with an increasing trend.

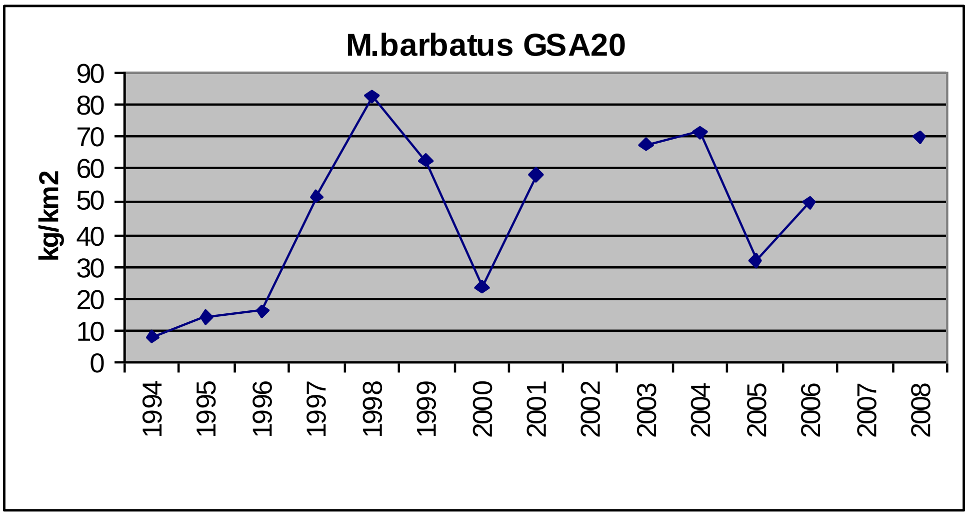



**Fig. 1.9.2.4. MEDITS abundance indices of red mullet in GSA 20.**

***Trends in growth***

No analyses were conducted

***Trends in maturity***

No analyses were conducted.

### 1.9.4 *Assessment of historic stock parameters*

#### 1.9.4.1 Method 1: Length Cohort Analysis-VIT

***Justification***

Pseudocohort analysis was performed for 2008 using VIT software (Lleonart and Salat, 1992) (see "data quality and availability" section).

***Input parameters***

Analysis was performed using number at age obtained from length frequencies distribution separated by slicing method with VIT software. Input parameters were taken from the STECF 12-10 (Sète, July 2012), for GSA 18.

**Table 1.9.4.1. Input data for LCA. Catch at length in 2008 of red mullet in GSA 20 by gear.**

| TL (cm) | 2008 OTB | 2008 GTR |
|---|---|---|
| 10 | 0 | 40762,98 |
| 11 | 75550,99 | 81525,96 |
| 12 | 833882 | 81525,96 |
| 13 | 2150962 | 692970,7 |
| 14 | 2520483 | 1834334 |
| 15 | 2241107 | 3913246 |
| 16 | 1513233 | 2894172 |
| 17 | 969919,3 | 2445779 |
| 18 | 395608 | 1019075 |
| 19 | 46634,72 | 407629,8 |
| 20 | 40230,98 | 203814,9 |
| 21 | 0 | 81525,96 |
| 22 | 0 | 40762,98 |

***Results***

The main results of the LCA are shown in table 1.9.4.2 and Figure. 1.9.4.1

**Table 1.9.4.2. Summary results of stock parameters derived from VIT model (Gear1= OTB; Gear2=GTR).**

| --- | Total | Gear 1 | Gear 2 |
|---|---|---|---|
| Catch mean age | 1,413 | 1,359 | 1,456 |
| Catch mean length | 14,68 | 14,396 | 14,909 |
| Mean F | 0,674 | 0,241 | 0,433 |
| Total catch | 874369,7 | 362151,7 | 512218 |
| Spawning Stock Biomass, SSB | 701009,79 | | |
| Number of recruits, R | 91424,05 | | |

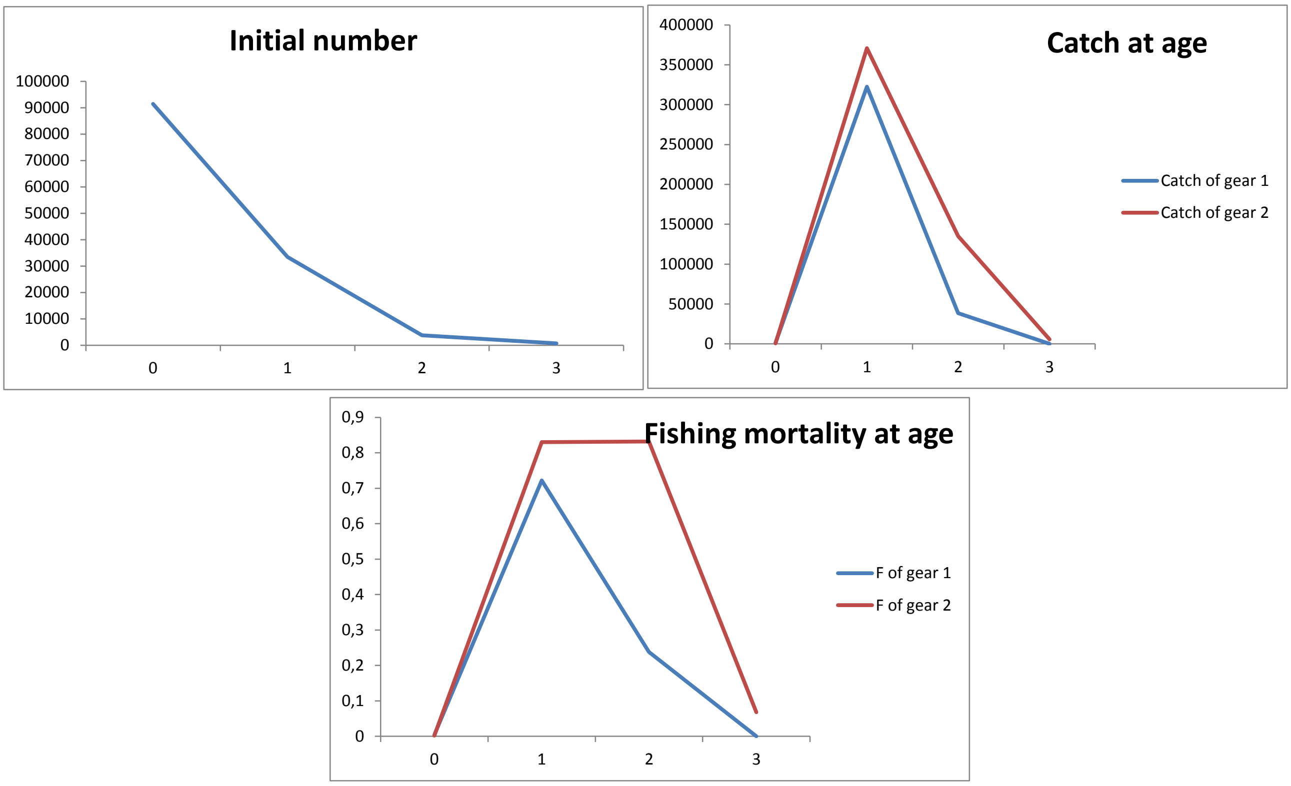



**Fig. 1.9.4.2. Initial number, catch at age calculated by slicing method with VIT software model model, and fishing mortality by gear (Gear1= OTB; Gear2=GTR). The main component of landings, by far, is age class 1.**

**Yield per recruit analysis results**

YPR analysis was performed using as input the output of the LCA by ages.

**Tab. 1.9.4.3. Results of the YPR analysis (Gear1= OTB; Gear2=GTR).**

| | Factor | Y/R | B/R | SSB | Y/R Gear 1 | Y/R Gear2 |
|---|---|---|---|---|---|---|
| F(0) | 0 | 0 | 40,874 | 37,09 | 0 | 0 |
| F(0.1) | 0,79 | 9,308 | 13,416 | 9,99 | 3,735 | 5,573 |
| Max Gear2 | 0,94 | 9,512 | 11,729 | 8,341 | 3,901 | 5,611 |
| phi=1 | 1,01 | 9,564 | 11,037 | 7,668 | 3,961 | 5,603 |
| Max(:) | 1,15 | 9,599 | 9,891 | 6,554 | 4,048 | 5,551 |
| Max Gear1 | 1,62 | 9,386 | 7,533 | 4,28 | 4,14 | 5,246 |
| phi=2 | 2 | 9,108 | 6,506 | 3,304 | 4,109 | 4,999 |

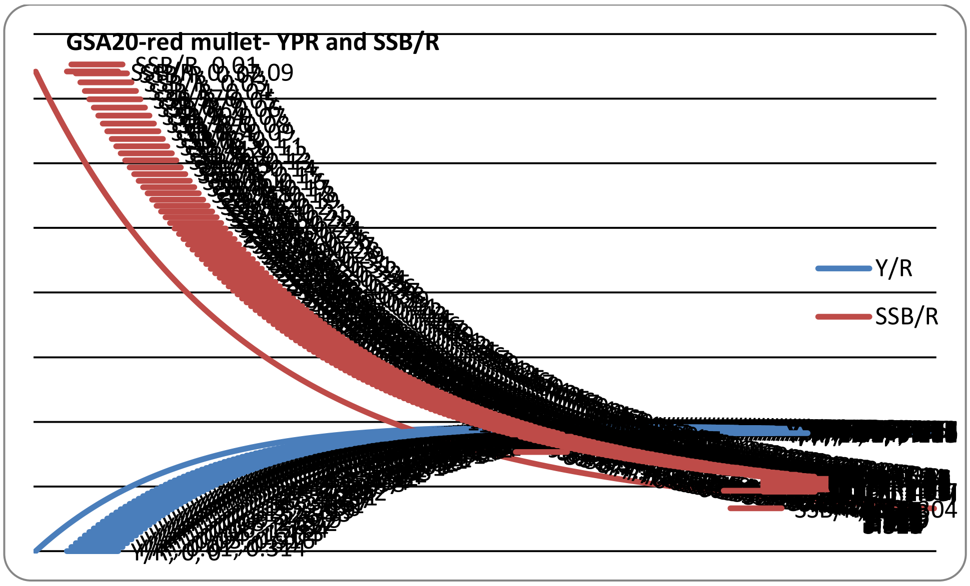



**Fig. 1.9.4.3. YPR outputs. YPR(left axis) and SSB/R (right axis), in grams, for red mullet in GSA20 in 2005. Note that x- axis indicates factor (not F value).**

**Table 1.9.4.4. YPR outputs. $F_{(0,1)}$ and $F_{max}$calculated from $F_{(0,1)}$ and $F_{max}$ factors and $F_{current}$.**

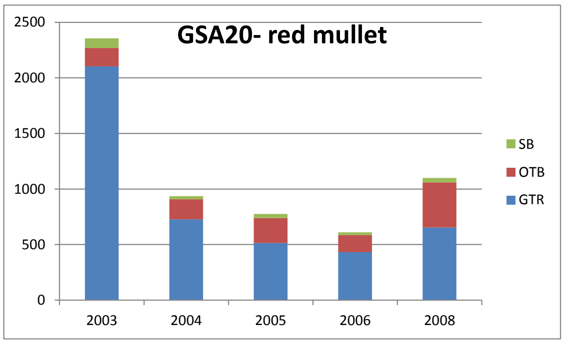
| Factor | | |
|---|---|---|
| 0,79 | F(0.1) | 0,532 |
| 1,15 | Fmax | 0,775 |
| 1,01 | Fcurrent | 0,674 |

$F_{(0,1)}$=0.53 is proposed as proxy of $F_{msy}$ for this stock. According to the F estimates derived from LCA, F in 2008 was larger than $F_{MSY}$. Based on this assessment, the stock of red mullet in GSA 20 is exploited unsustainably.

**Data quality and availability**

Data used in the LCA were taken from the access database "SGMED 2009 fisheries data 20100118GRConly". A number of gaps and inconsistencies were found in the DCR Fisheries data, which determined the years that could be used as input for LCA. The main problem is that landings data by gear taken from the database or calculated from the size distributions by gear are rather different, due to the lack of data on sizes. Taking into account that only in 2008 sizes were available for OTB and GTR, this year was chosen as input for LCA.

No data on discards available and no data for 2007.



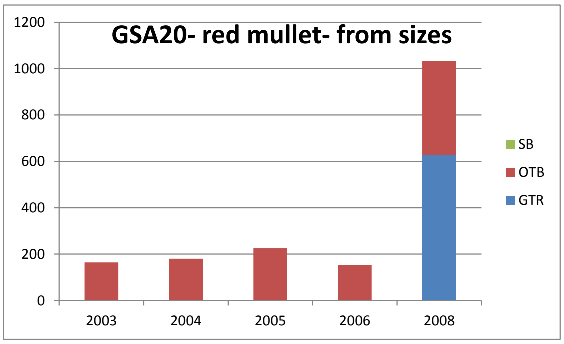




**Fig. 1.9.4.7. Red mullet annual landings (t) in GSA 20, as taken from the access database (left) and calculated from the annual size distributions by gear (rigth).**

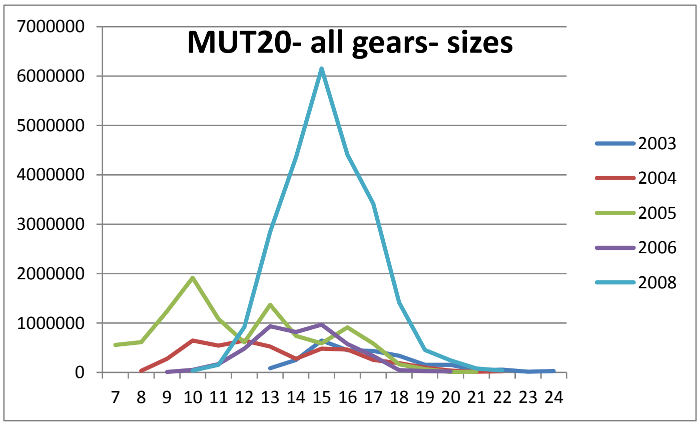



**Fig. 1.9.4.8. Red mullet annual size distributions (numbers) in GSA20 (data source: access database)**

### 1.9.4.2 Method 2: Stock-Production model

***Justification***

The analysis was performed using the ASPIC.5 software (A Stock-Production model Incorporating Covariates) (Prager, 1994, 2005) assuming a Schaefer (1954) model. This program implements a non-equilibrium, continuous-time, observation-error estimator for the dynamic production model (Schnute, 1977; Prager, 1994). The model was used to estimate *r* (the intrinsic rate of population growth), *MSY*, the ratios of both current biomass or *F* to the biomass or F at which *MSY* can be attained, and *q* (the catchability coefficient, the proportion of total stock removed by one unit of fishing effort).

***Input parameters***

Input data consist in 4 sets of time series from 1964 to 2007 of total landings (in tons) and fishing effort expressed as days fishing x HP. Data regards landings and effort related to trawling, purse seining, beach seines and other small scale fisheries mostly including set nets. No information was available in order to determine more detailed specific effort targeting the stock in question between each fishing strategy and hence for the analysis it was assumed that neither targets for each fishing technique nor areas did change along the studied period.

MEDITS trawls surveys estimates of the index of abundance between 1994 and 2008 were available but the series was incomplete, very short and showing high fluctuating values and hence such information was not included in this analysis. For this reason, no analysis based on survey data were performed even though an attempt of including such information in the analysis was done. Such attempt resulted unsuccessful because lacking of enough correlation with the cpue's time series.

Considering the lower importance of beach seines and purse seines in the overall catch and also that the stocks in question were not the target of such fisheries, a lower weight were assigned to the information proceeding from such fisheries for the computations. As a setting option of ASPIC, priority (more weight) was assigned to the information on landings than to effort, considered the last one measured with lower precision.

Several models were tested (Schaefer, Fox, Generalized), but the only that supplied fairly good fittings and reasonable results was the logistic Schaefer model. From the bootstrap results, bias-corrected (BC) confidence intervals were computed by standard methods (Efron and Gong 1983). 1000 bootstrap trials were performed computing 90% confidence intervals.

**Table 1.9.4.5. ASPIC input parameters of the FIT mode for GSA 20.**

| B1/K | MSY | Range of MSY | K | Range of K | Fishing fleet | q (mean (CPUE) / 2*max(Y)) |
|---|---|---|---|---|---|---|
| 0.5 | 4.00E+2 | 3.00E+02 to 1.50E+03 | 1.300E+03 | 8.00E+02 to 1.200E+04 | Trawlers<br>Purse seine<br>Beach seine<br>Small scale | 3.364E-08<br>3.775E-08<br>3.178E-08<br>4.522E-08 |

***Results***

As follows the main results of the analysis for the two areas are shown in Table 1.9.4.6:

**Table 1.9.4.6. Results of ASPIC model for *Mullus barbatus* in GSA20.**

MANAGEMENT and DERIVED PARAMETER ESTIMATES -----------------------------------------------------------------------------------------------------------------------

| Model | MSY (tons) | $B_{MSY}$ (tons) | $F_{MSY}$ | $f_{MSY}$ Beach seine | $f_{MSY}$ Trawl | $f_{MSY}$ Purse seine | $f_{MSY}$ Small scale |
|---|---|---|---|---|---|---|---|
| **Logistic** | 1175 | 4012 | 0.294 | 4.015E+07 | 3.506E+07 | 1.059E+08 | 4.210E+07 |

| Model | MSY 80% lower | MSY | MSY 80% higher | $F_{MSY}$ 80% lower | $F_{MSY}$ | $F_{MSY}$ 80% higher |
|---|---|---|---|---|---|---|
| **Logistic** | 1009 | 1175 | 1294 | 0.239 | 0.269 | 0.298 |

| Parameter | Estimate |
|---|---|
| B./Bmsy Ratio: B(2008)/Bmsy | 1.257 |
| F./Fmsy Ratio: F(2007)/Fmsy | 0. 653 |
| r | 0.588 |

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)
------------------------------------------------------------------------------------------------------------------------

| Obs | Year or ID | Estimated total F mort | Estimated starting biomass | Estimated average biomass | Observed total yield | Model total yield | Estimated surplus production | Ratio of F mort to Fmsy | Ratio of biomass to Bmsy |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1964 | 0.020 | 1.403E+04 | 1.184E+04 | 2.344E+02 | 2.344E+02 | -3.424E+03 | 6.734E-02 | 3.507E+00 |
| 2 | 1965 | 0.029 | 1.037E+04 | 9.572E+03 | 2.785E+02 | 2.785E+02 | -1.117E+03 | 9.903E-02 | 2.592E+00 |
| 3 | 1966 | 0.030 | 8.972E+03 | 8.610E+03 | 2.596E+02 | 2.596E+02 | -3.884E+02 | 1.026E-01 | 2.243E+00 |
| 4 | 1967 | 0.037 | 8.324E+03 | 8.118E+03 | 3.023E+02 | 3.023E+02 | -7.094E+01 | 1.267E-01 | 2.081E+00 |
| 5 | 1968 | 0.037 | 7.951E+03 | 7.842E+03 | 2.880E+02 | 2.880E+02 | 9.063E+01 | 1.250E-01 | 1.988E+00 |
| 6 | 1969 | 0.039 | 7.753E+03 | 7.685E+03 | 3.031E+02 | 3.031E+02 | 1.778E+02 | 1.342E-01 | 1.938E+00 |
| 7 | 1970 | 0.043 | 7.628E+03 | 7.578E+03 | 3.270E+02 | 3.270E+02 | 2.350E+02 | 1.469E-01 | 1.907E+00 |
| 8 | 1971 | 0.044 | 7.536E+03 | 7.506E+03 | 3.283E+02 | 3.283E+02 | 2.725E+02 | 1.489E-01 | 1.884E+00 |
| 9 | 1972 | 0.039 | 7.480E+03 | 7.476E+03 | 2.947E+02 | 2.947E+02 | 2.875E+02 | 1.341E-01 | 1.870E+00 |
| 10 | 1973 | 0.042 | 7.473E+03 | 7.462E+03 | 3.148E+02 | 3.148E+02 | 2.948E+02 | 1.436E-01 | 1.868E+00 |
| 11 | 1974 | 0.050 | 7.453E+03 | 7.423E+03 | 3.689E+02 | 3.689E+02 | 3.144E+02 | 1.691E-01 | 1.863E+00 |
| 12 | 1975 | 0.052 | 7.399E+03 | 7.373E+03 | 3.860E+02 | 3.860E+02 | 3.394E+02 | 1.782E-01 | 1.850E+00 |
| 13 | 1976 | 0.058 | 7.352E+03 | 7.319E+03 | 4.278E+02 | 4.278E+02 | 3.663E+02 | 1.989E-01 | 1.838E+00 |
| 14 | 1977 | 0.058 | 7.291E+03 | 7.272E+03 | 4.227E+02 | 4.227E+02 | 3.888E+02 | 1.978E-01 | 1.823E+00 |
| 15 | 1978 | 0.069 | 7.257E+03 | 7.211E+03 | 5.010E+02 | 5.010E+02 | 4.177E+02 | 2.364E-01 | 1.814E+00 |
| 16 | 1979 | 0.078 | 7.174E+03 | 7.120E+03 | 5.586E+02 | 5.586E+02 | 4.602E+02 | 2.670E-01 | 1.793E+00 |
| 17 | 1980 | 0.080 | 7.075E+03 | 7.039E+03 | 5.627E+02 | 5.627E+02 | 4.967E+02 | 2.720E-01 | 1.769E+00 |
| 18 | 1981 | 0.087 | 7.009E+03 | 6.966E+03 | 6.078E+02 | 6.078E+02 | 5.289E+02 | 2.969E-01 | 1.752E+00 |
| 19 | 1982 | 0.092 | 6.930E+03 | 6.890E+03 | 6.360E+02 | 6.360E+02 | 5.618E+02 | 3.141E-01 | 1.733E+00 |
| 20 | 1983 | 0.096 | 6.856E+03 | 6.821E+03 | 6.554E+02 | 6.554E+02 | 5.907E+02 | 3.270E-01 | 1.714E+00 |
| 21 | 1984 | 0.104 | 6.791E+03 | 6.747E+03 | 7.040E+02 | 7.040E+02 | 6.212E+02 | 3.551E-01 | 1.698E+00 |
| 22 | 1985 | 0.104 | 6.709E+03 | 6.682E+03 | 6.956E+02 | 6.956E+02 | 6.469E+02 | 3.543E-01 | 1.677E+00 |
| 23 | 1986 | 0.093 | 6.660E+03 | 6.675E+03 | 6.219E+02 | 6.219E+02 | 6.497E+02 | 3.170E-01 | 1.665E+00 |
| 24 | 1987 | 0.108 | 6.688E+03 | 6.655E+03 | 7.180E+02 | 7.180E+02 | 6.575E+02 | 3.671E-01 | 1.672E+00 |
| 25 | 1988 | 0.177 | 6.627E+03 | 6.415E+03 | 1.136E+03 | 1.136E+03 | 7.460E+02 | 6.027E-01 | 1.657E+00 |
| 26 | 1989 | 0.157 | 6.237E+03 | 6.164E+03 | 9.673E+02 | 9.673E+02 | 8.313E+02 | 5.341E-01 | 1.559E+00 |
| 27 | 1990 | 0.147 | 6.101E+03 | 6.082E+03 | 8.925E+02 | 8.925E+02 | 8.569E+02 | 4.994E-01 | 1.525E+00 |
| 28 | 1991 | 0.213 | 6.066E+03 | 5.883E+03 | 1.252E+03 | 1.252E+03 | 9.142E+02 | 7.240E-01 | 1.516E+00 |
| 29 | 1992 | 0.222 | 5.728E+03 | 5.592E+03 | 1.242E+03 | 1.242E+03 | 9.888E+02 | 7.559E-01 | 1.432E+00 |
| 30 | 1993 | 0.255 | 5.475E+03 | 5.310E+03 | 1.355E+03 | 1.355E+03 | 1.049E+03 | 8.682E-01 | 1.369E+00 |
| 31 | 1994 | 0.233 | 5.169E+03 | 5.111E+03 | 1.192E+03 | 1.192E+03 | 1.085E+03 | 7.936E-01 | 1.292E+00 |
| 32 | 1995 | 0.236 | 5.061E+03 | 5.016E+03 | 1.186E+03 | 1.186E+03 | 1.100E+03 | 8.046E-01 | 1.265E+00 |
| 33 | 1996 | 0.260 | 4.975E+03 | 4.892E+03 | 1.273E+03 | 1.273E+03 | 1.117E+03 | 8.854E-01 | 1.244E+00 |
| 34 | 1997 | 0.265 | 4.819E+03 | 4.752E+03 | 1.260E+03 | 1.260E+03 | 1.134E+03 | 9.023E-01 | 1.205E+00 |
| 35 | 1998 | 0.263 | 4.693E+03 | 4.651E+03 | 1.223E+03 | 1.223E+03 | 1.144E+03 | 8.947E-01 | 1.173E+00 |
| 36 | 1999 | 0.262 | 4.614E+03 | 4.588E+03 | 1.200E+03 | 1.200E+03 | 1.150E+03 | 8.904E-01 | 1.154E+00 |
| 37 | 2000 | 0.254 | 4.564E+03 | 4.562E+03 | 1.157E+03 | 1.157E+03 | 1.152E+03 | 8.630E-01 | 1.141E+00 |
| 38 | 2001 | 0.252 | 4.559E+03 | 4.561E+03 | 1.149E+03 | 1.149E+03 | 1.152E+03 | 8.576E-01 | 1.140E+00 |
| 39 | 2002 | 0.244 | 4.562E+03 | 4.579E+03 | 1.119E+03 | 1.119E+03 | 1.151E+03 | 8.318E-01 | 1.141E+00 |
| 40 | 2003 | 0.247 | 4.594E+03 | 4.600E+03 | 1.138E+03 | 1.138E+03 | 1.149E+03 | 8.418E-01 | 1.148E+00 |
| 41 | 2004 | 0.261 | 4.605E+03 | 4.581E+03 | 1.195E+03 | 1.195E+03 | 1.151E+03 | 8.880E-01 | 1.151E+00 |
| 42 | 2005 | 0.223 | 4.560E+03 | 4.621E+03 | 1.032E+03 | 1.032E+03 | 1.147E+03 | 7.599E-01 | 1.140E+00 |
| 43 | 2006 | 0.195 | 4.675E+03 | 4.779E+03 | 9.340E+02 | 9.340E+02 | 1.131E+03 | 6.651E-01 | 1.169E+00 |
| 44 | 2007 | 0.192 | 4.872E+03 | 4.954E+03 | 9.520E+02 | 9.520E+02 | 1.108E+03 | 6.539E-01 | 1.218E+00 |
| 45 | 2008 | | 5.028E+03 | | | | 1.2 | | |

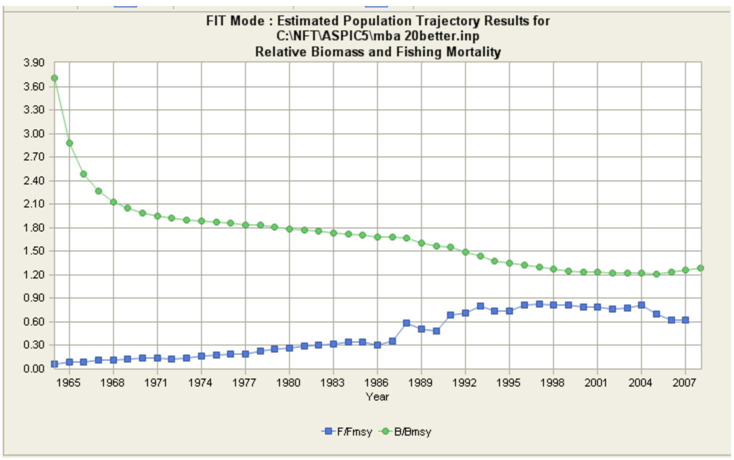



**Fig.1.9.4.9. F/F$_{MSY}$ and B/B$_{MSY}$ of red mullet in GSA 20 estimated for each year**

F/F$_{MSY}$ and B/B$_{MSY}$ estimated for each year are showed Figure 1.9.4.9.

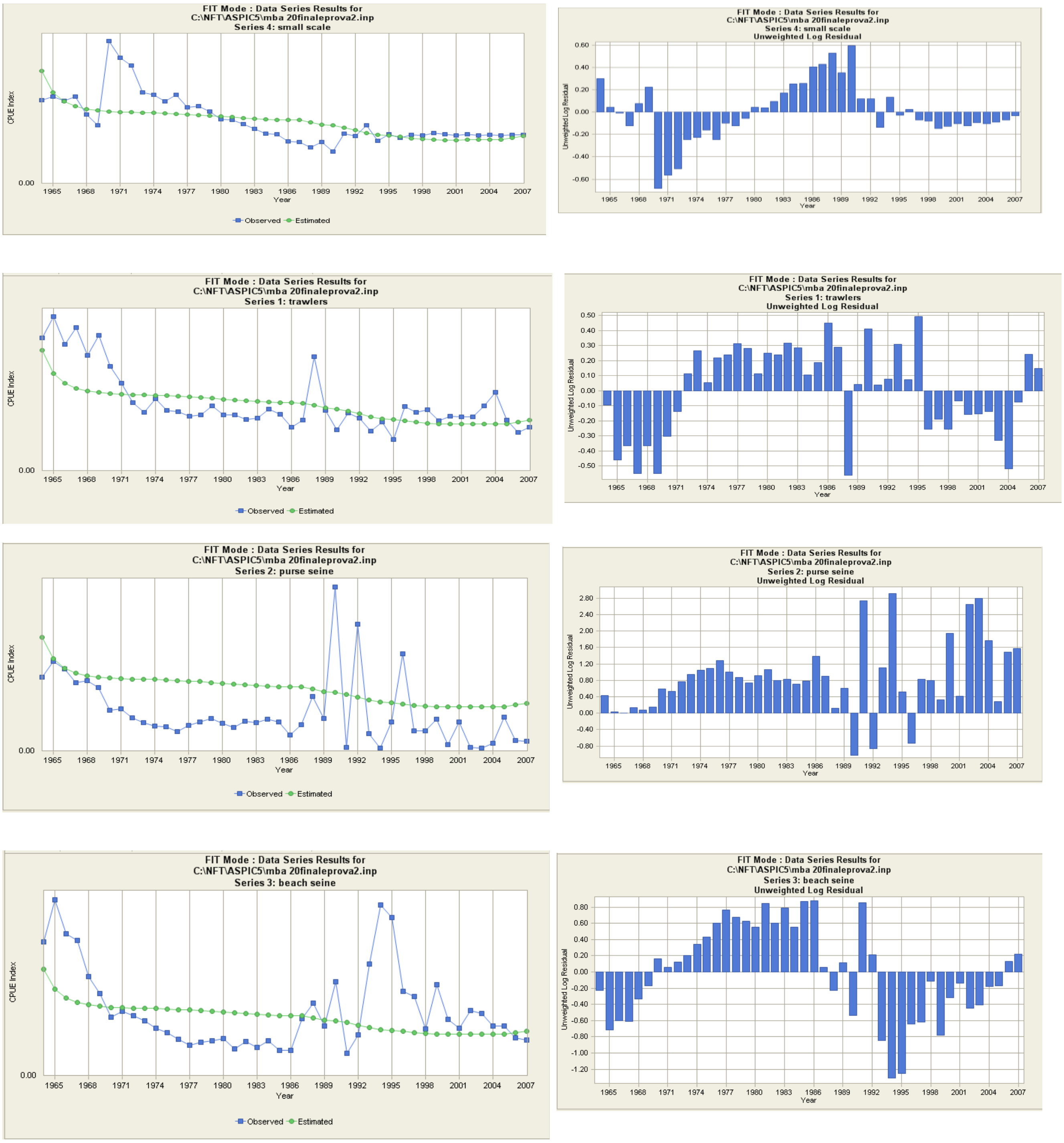



**Fig.1.9.4.10. Model fitting for each gear/strategy and model residuals.**

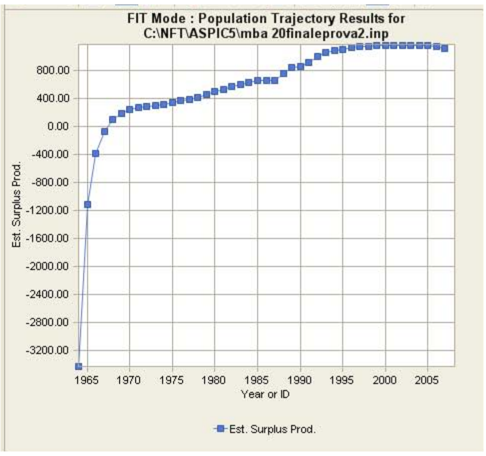



**Fig.1.9.4.11. Estimated surplus production of *Mullus barbatus* in GSA 20 using the Logistic Schaefer model for the period 1964-2008.**

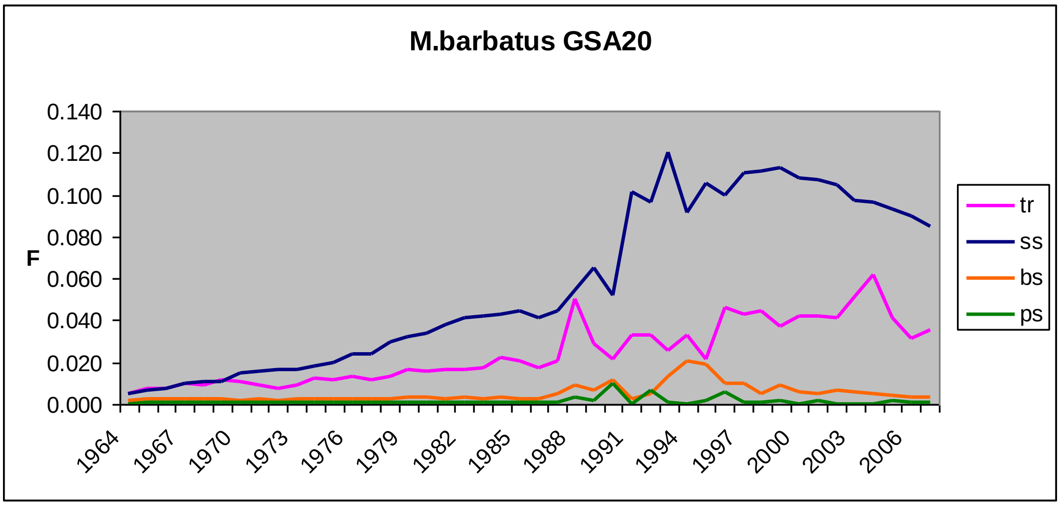



**Fig.1.9.4.12. F vector by gear for *Mullus barbatus* in GSA20 (tr (trawlers); ss (small-scale); bs (beach seines); ps (purse seiners)).**

The results of the production models suggest that red mullet in the GSA 20 is exploited sustainably, considering that the current F is 0.65 times above the $F_{MSY}$ ($F/F_{MSY}$ =1.65). The biomass at sea, after five decades of higher exploitation, is above the $B_{msy}$, with the current biomass being around 120% of $B_{MSY}$ ($B/B_{MSY}$ = 1.21).

**Data quality and availability**

Data used in ASPIC proceed from a reconstruction of landings derived from different sources. A number of gaps and inconsistencies can be found. The main problem regards the quality of effort information, which regards the total effort by type of gear or group of gears without distinction on the metier. For species that shows a limited bathymetric distribution as *Mullus barbatus*, the lack of such information does not allow to quantify which is the correct amount of effort directed to the species in question, having the bathymetric distribution of some fleets (i.e. trawlers) more wide depth range. Moreover, no data on discards is available.
The lack of information obliged to assume that the pattern of spatial distribution and target of the fleets remained almost unchanged along the analysed period and also the discards rate. Only in this

way it is possible to assume that the observed changes in abundance (CPUE) are mainly due to changes in fishing pressure on the stock in question.

### 1.9.4.3 Method 1: SURBA (Survey Based Assessment)

***Justification***

The relatively long time series of data available from the MEDITS surveys provided the most useful data set to analyse the trend of *Mullus barbatus* stock in GSA 20. The MEDITS indices of abundance (n/hour) for red mullet in GSA 20, covering the period 1994-2008 (except years 2002 and 2007) were analysed using SURBA (SURvey-Based stock Assessment approach, Needle, 2003). The annual standardized size distributions (1 cm total length class, Fig. 1.9.4.13) from MEDITS were converted in age distributions using L2AGE4 software (Fig. 1.9.4.14).

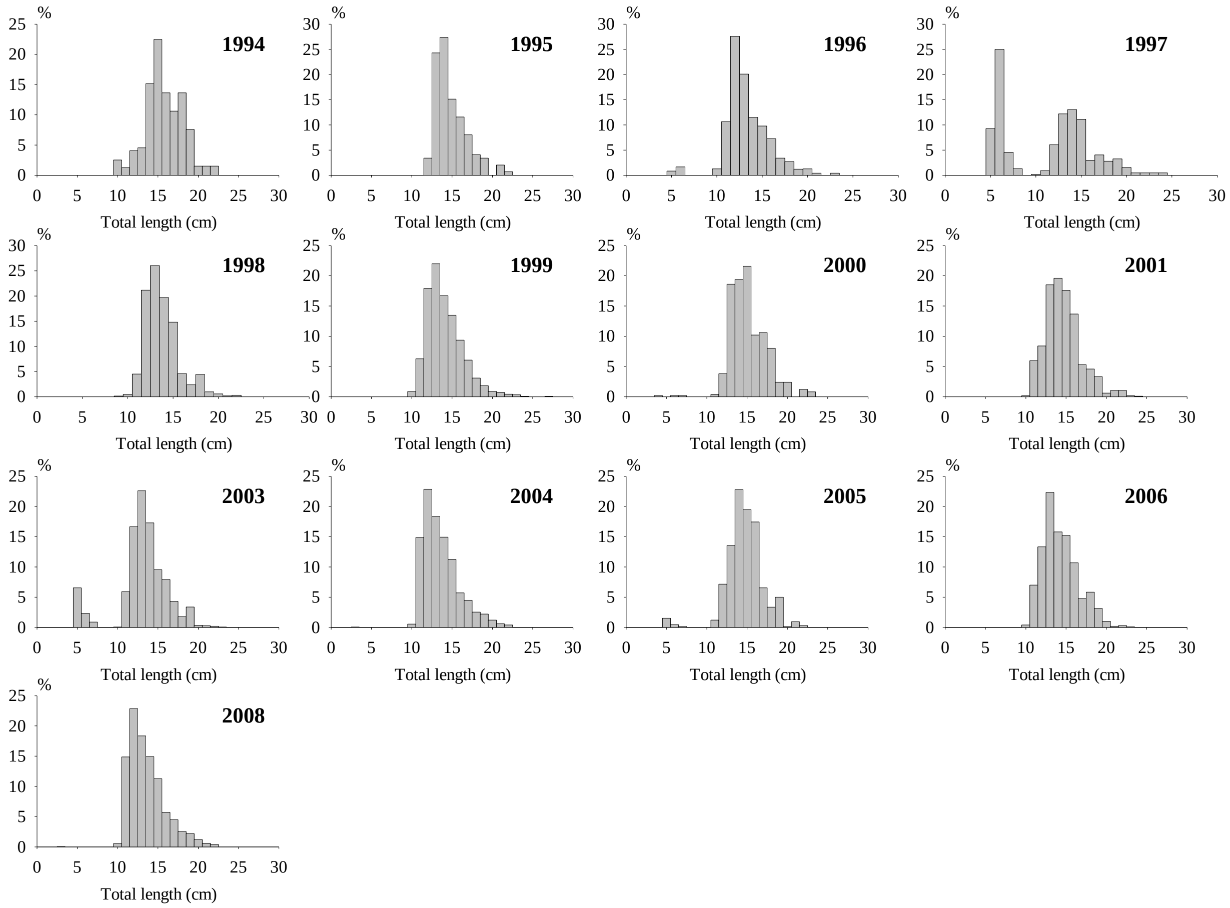



**Fig. 1.9.4.13. MEDITS length frequency distributions of red mullet in the GSA 20.**

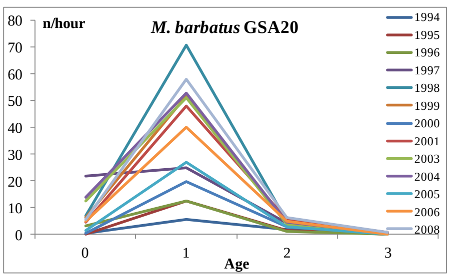



**Fig. 1.9.4.14. Numbers at age distributions of red mullet from MEDITS 1994-2008 in GSA 20.**

Input parameters

Table 1.9.4.7 shows the input parameters used to run SURBA.

Single survey exploratory SURBA 2.2 model runs were carried out fitting constant catchability (1.0 for all ages)

The model settings are given below:
Year range: 1994-2008, 2002 and 2007 lacking
Age range: 0-3+
Age weighting: 0.8 (ages 0), 1 (ages 1), 0.60 (age 2-3)

**Table 1.9.4.7. Input parameters of SURBA.**

**Growth parameters**

| L∞ | k | t0 | a | b |
|---|---|---|---|---|
| 30 | 0.4 | -0.3 | 0.0083 | 3.1134 |

**Proportion of mature**

| Age | | | |
|---|---|---|---|
| 0 | 1 | 2 | 3+ |
| 0.16 | 0.92 | 1 | 1 |

**Natural mortality**

| Age | | | |
|---|---|---|---|
| 0 | 1 | 2 | 3+ |
| 1 | 0.61 | 0.54 | 0.47 |

#### 1.9.4.3.1 Results

Comparative scatterplots at age indicated a poor consistency of the MEDITS data, between ages 0-3 and ages 1-3 (Fig. 1.9.4.15).

The trends in F, SSB and recruitment at age 0 from SURBA run, and the model residuals are given in Figures 1.9.4.16-17. The retrospectives for the MEDITS survey data are given in Figure 1.9.4.18.

SURBA estimated large oscillations in the temporal effect (f), with abnormal values after the years in which data was not available. The age effect showed the highest values for ages 2 and 3+.

Total mortality (Z) showed oscillations with minimum values for 1996, 2000 and 2005-2006 and maximum in 1994, 1998 and 2003. F (bootstrapped estimates) also showed important oscillations. The estimated relative SSB did not show any clear trend.

The residuals at age showed large values for ages 0 and 1. However, both ages were kept in the analysis as results for a new analysis only with ages 2 and 3 were not considered reliable. Residuals at ages 2-3 didn’t show any pattern.

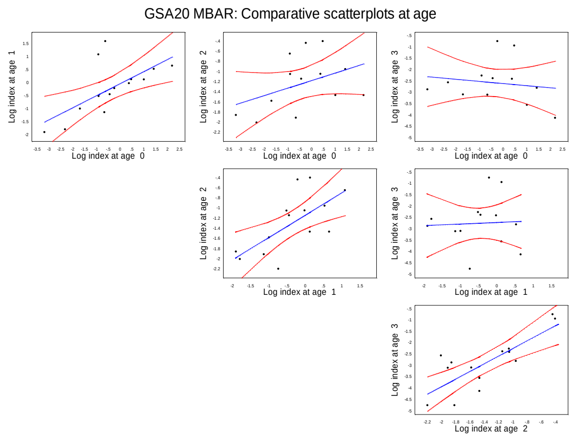
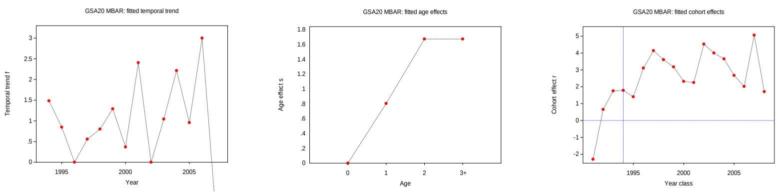
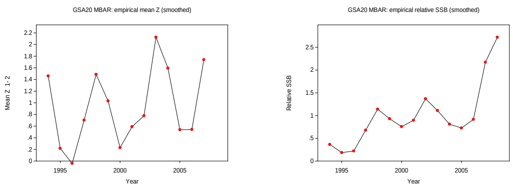



**Fig. 1.9.4.15. Red mullet in GSA 20: Output from SURBA plots for MEDITS survey, showing age scatter plots.**

A)




B)




C)

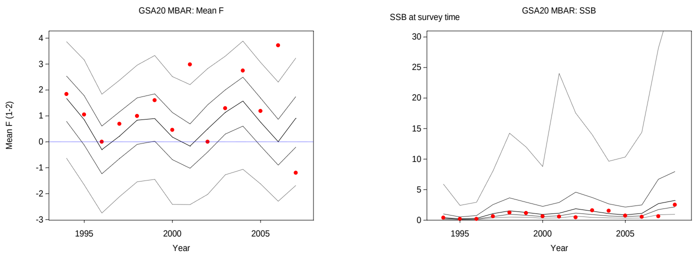
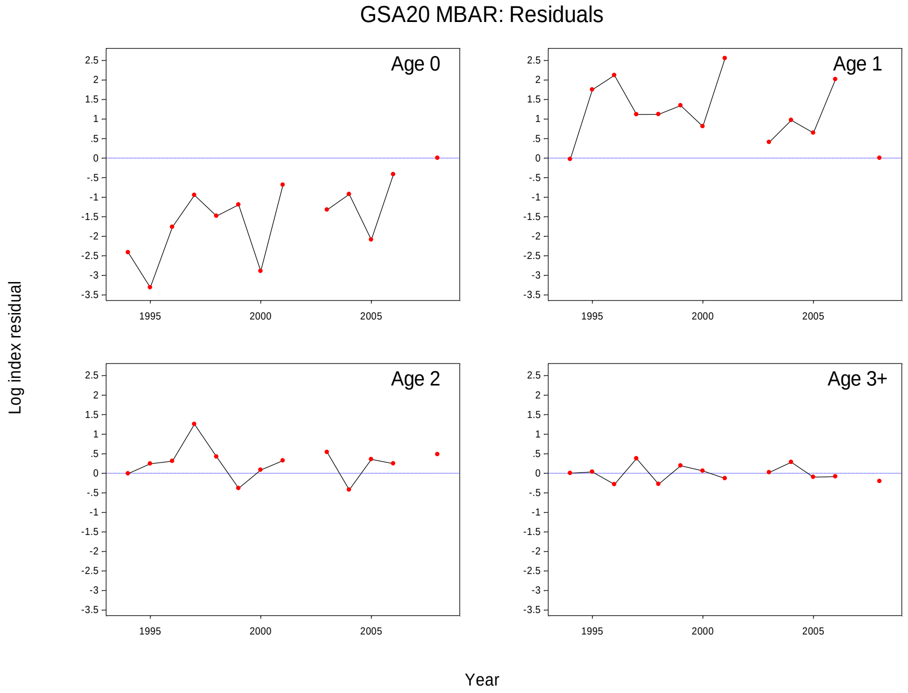



**Fig. 19.4.16. SURBA estimates for red mullet in GSA 20. A) model parameters. B) total mortality and SSB C) bootstrapped (lines) and fitted (points) estimates of $F_{1-2}$ and SSB, and empirical relative SSB, solid and dotted lines are respectively 50% and 5- 95% of bootstrapped estimates.**

A)




B)

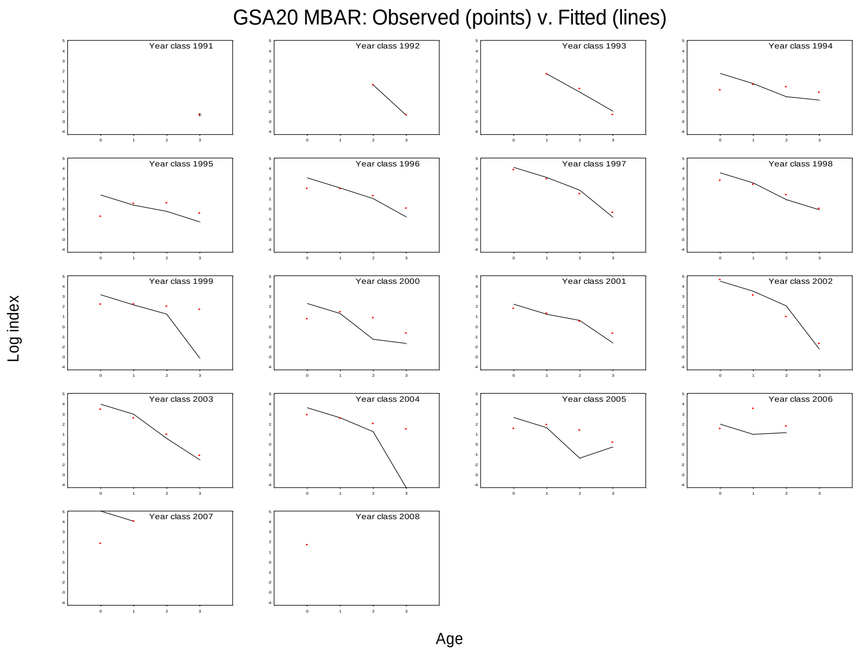



**Fig. 1.9.4.17. SURBA model diagnostic for red mullet in GSA 20. A) Temporal trend in residuals by age B) Observed (points) and fitted (lines) year classes.**

The model provides inconsistent estimates concerning the mean F. Extremely low values for the relative F were estimated in 1996, 2000 and 2002. Moreover it indicates that the assumed catchability pattern drives the estimates instead of the data themselves. However, these results are likely due to poor data fit and do not represent actual trends in mean F and relative SSB.

Model diagnostics are shown in the following Fig. 19.1.1.16-18 indicating poor data fit in several cohorts. Retrospective analysis was applied in the SURBA model for the 1994-2008 period with 8 years backward analysis. Results are presented in Fig. 17 showing retrospective bias in the case of temporal trend and age effect.

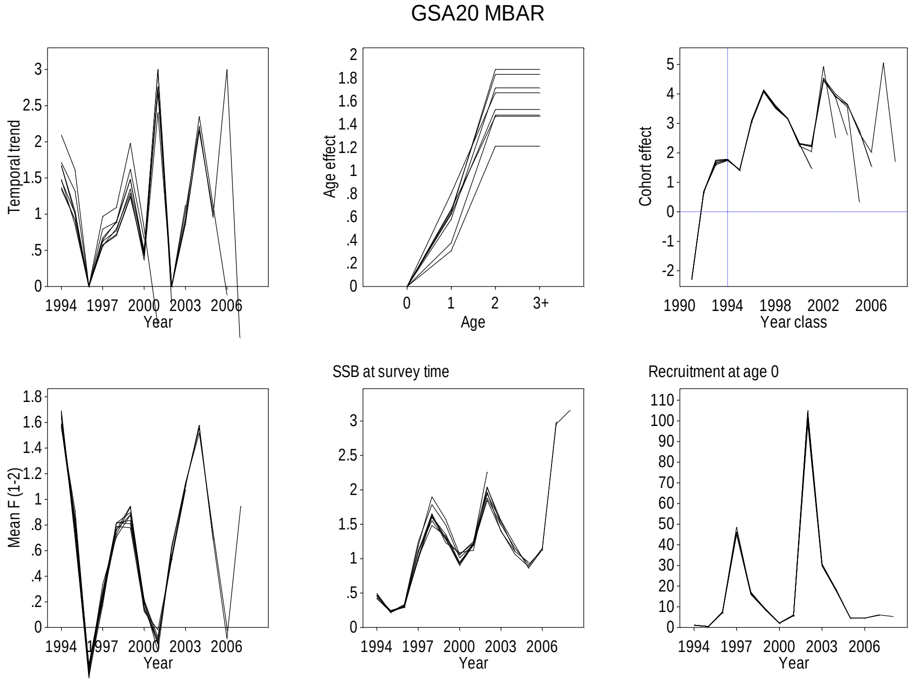



**Fig. 1.9.4.18. SURBA model of red mullet in GSA 20: retrospective analysis.**

### *State of the spawning stock size*

In the absence of proposed or agreed references, STECF ad hoc Working Group is unable to fully evaluate the state of the stock and provide scientific advice.

No reliable estimates on the trend in the spawning stock size can be assessed based on SURBA results, which presented poor data fit.

The current biomass estimated by the ASPIC model is 1.21 of $B_{MSY}$ ($B/B_{MSY}$ = 1.21), thus the current biomass is above the estimated biomass reference point for this stock.

### *State of recruitment*

No reliable estimates on the trend in the recruitment size can be assessed based on SURBA results, which presented poor data fit.

### *State of exploitation*

The reference point estimated by ASPIC with the logistic model (0.27) suggests that red mullet in GSA 20 is exploited sustainably ($F_{curr}/F_{MSY}$ in 2008=0.65).

No reliable estimates on the trend in F can be assessed based on SURBA results, which presented poor data fit.

$F_{(0,1)}$=0.532 is proposed as proxy of $F_{msy}$ for this stock. According to the F estimates derived from LCA, F in 2008 was larger than $F_{MSY}$. Based on this assessment, the stock of red mullet in GSA 20 is exploited unsustainably.

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Efron, B. E., and G. Gong. 1983. A leisurely look at the bootstrap, the jackknife, and cross-validation. American Statistician 47: 36–48.

Prager, M.H. 2005. User’s Manual for ASPIC: Stock Production Model Incorporating Covariates (ver. 5) and Auxiliary Programs. National Marine Fisheries Service. Population Dynamic Team.

Reñones O.,_Massuti E., Morales- Nin B. (1985) Life history of the red mullet Mullus surmuletus from the bottom-trawl fishery off the Island of Majorca (north-west Mediterranean) Marine Biology (1995) 123:411-419).

## 1.10 Stock assessment of red mullet *Mullus barbatus* in GSA 22&23

### 1.10.1 *Stock identification and biological features*

#### 1.10.1.1 Stock Identification

Red mullet is distributed along the shelf of all the Mediterranean countries. The species can be found at depths over 200m, but is mainly concentrated in the depth range 0-100m. All the year classes and nursery and spawning areas are well distributed along the narrow Mediterranean shelves. There is not a definition of unit stocks in the area.

#### 1.10.1.2 Growth and Natural Mortality

*Mullus barbatus* is a fast growing species. The parameters used are reported below and are considered suitable for the description of an average growth performance valid for all the analysed GSAs.

The following growth parameters considered representative for *M. barbatus* in GSA 20 were utilized in the successive analyses (taken from STECF 12-10 report and used for *M. barbatus* in GSA 18)

Growth parameters: $L_\infty$= 30 cm; K=0.4; a=0083; b=3.1134

An M vector derived from PRODBIOM (Abella et al., 1997) was used

**Natural mortality**

| Age | | | |
|---|---|---|---|
| 0 | 1 | 2 | 3+ |
| 1 | 0.61 | 0.54 | 0.47 |

#### 1.10.1.3 Maturity

The species reaches massively the sexual maturity at one year old. Observations of proportion of mature individuals by size and analysis with the standard procedure have produced the following sizes at age maturity by sex.

**Proportion of mature**

| Age | | | |
|---|---|---|---|
| 0 | 1 | 2 | 3+ |
| 0.16 | 0.92 | 1 | 1 |

### 1.10.2 *Fisheries*

#### 1.10.2.1 General description of fisheries

*Mullus barbatus* is among the most commercially valuable species in the areas and is an important component of a species assemblage that is the target of the bottom trawling fleets and small scale fisheries operating near shore. The small mesh size of the cod end in all cases defines a very precocious size/age of first capture. The species is caught by small-scale fisheries using set nets and bottom trawl. The trawlers and the small scale artisanal vessels are the main gear that exploit the species in the area. On average in the analysed period, the main catches of *Mullus barbatus* in GSA 22 and 23 corresponded to trawlers 48%, purse seiners 1%, beach seines 5% and small scale 46%.

The exerted fishing pressure on this species on different GSAs may be quite different because conditioned by the structural composition of the fractions of the fleets that operate close to their respective ports, by the characteristics of the potentially exploitable grounds and also by differences in the fisheries' target choices among fleets and zones. *Mullus barbatus* catch rates are higher during the post-recruitment period (from September to November).

#### 1.10.2.2 Management regulations applicable in 2009 and changes in 2010

From Gozalvo et al. (2011):

- Bottom trawl:
    - Minimum distance from the coast
    - Mesh size dimensions
    - Temporal closure
    - Minimum fishing depth
- Netters:
    - Maximum dimension of nets
    - Minimum mesh size
    - Type of thread

Management regulations applicable in 2007 and 2008

RD 917/1966 is the principal law regulating the operation of trawlers. Although this law is still in effect, it has been superseded by EC Regulation 1626/1994, and its replacement Regulation 1967/2006. The main restrictions established by Greek and European legislation are:

(1) establishment of a total exclusion zone one and a half mile from the coastline of the mainland and the islands,

(2) a total fishing ban from the 1st of June till the end of September,

(3) establishment of a total exclusion zone which is: either a zone three miles from the coastal line or a zone shallower than 50 m,

(4) minimum cod-end mesh size is 40 mm (EC regulation 1967/2006); from 1 July 2008, the net shall be replaced by a square-meshed net of 40 mm at the cod-end or, at the duly justified request of the ship owner, by a diamond meshed net of 50 mm.

Additional restrictions exist for bottom trawling in specific areas: in Amvrakikos Gulf and some parts of the Korinthiakos Gulf and the Ionian Sea, trawling is prohibited all year around, while in Patraikos Gulf trawling is prohibited from the 1st of March till the end of November and in the entire Korinthiakos is prohibited from from the 1st of April till the end of November (Presidential Decree 698/81).

The operation of the bottom set nets is subject to the following main restrictions:
(1) the maximum total length of the trammel net is 6000 m.
(2) the minimum mesh size opening is 16 mm.
(3) monofilament or twine diameter of the net should not exceed 0.5 mm.
(4) the maximum drop of a combined trammel and gill net should not exceed 10 m and the length of combined nets should not exceed 2,500 m.

For the bottom longlines the only restriction derives from ER 1967/2006 and referred to maximum number of hooks per fishers (1000 hooks) and the total maximum number of hooks per vessel (5000 hooks)

#### 1.10.2.3 Catches

***Landings***

Small scale fishing vessels and bottom trawlers dominate the landings. Landings data used in the production model are estimates of landings and effort for GSA 22 & 23 provided in Section 1 of this report, by Moutoupolous and Stergiou (2012) and from the FAO-FISHSTAT GFCM database.

Landings show a very high seasonal variability, with peaks at the end of summer (September) determined by the increase in availability/vulnerability after the massive recruitment on the coastal area.

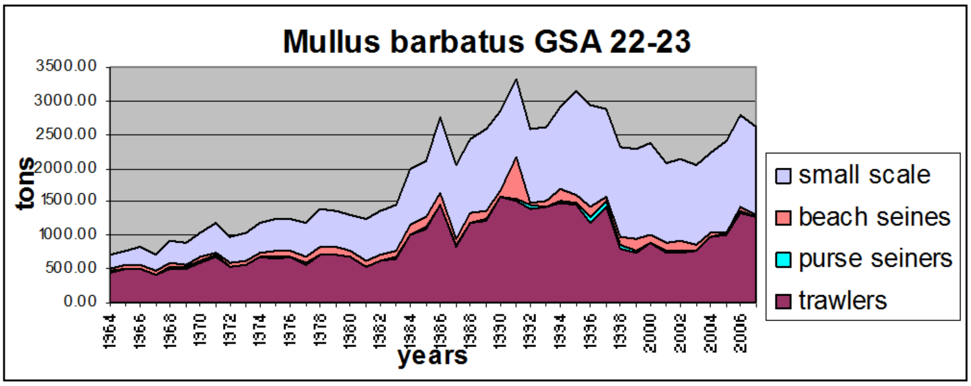



**Fig. 1.10.2.1. Annual landings (t) by fishing technique *M.barbatus* in GSA 22&23 during 1964-2007.**

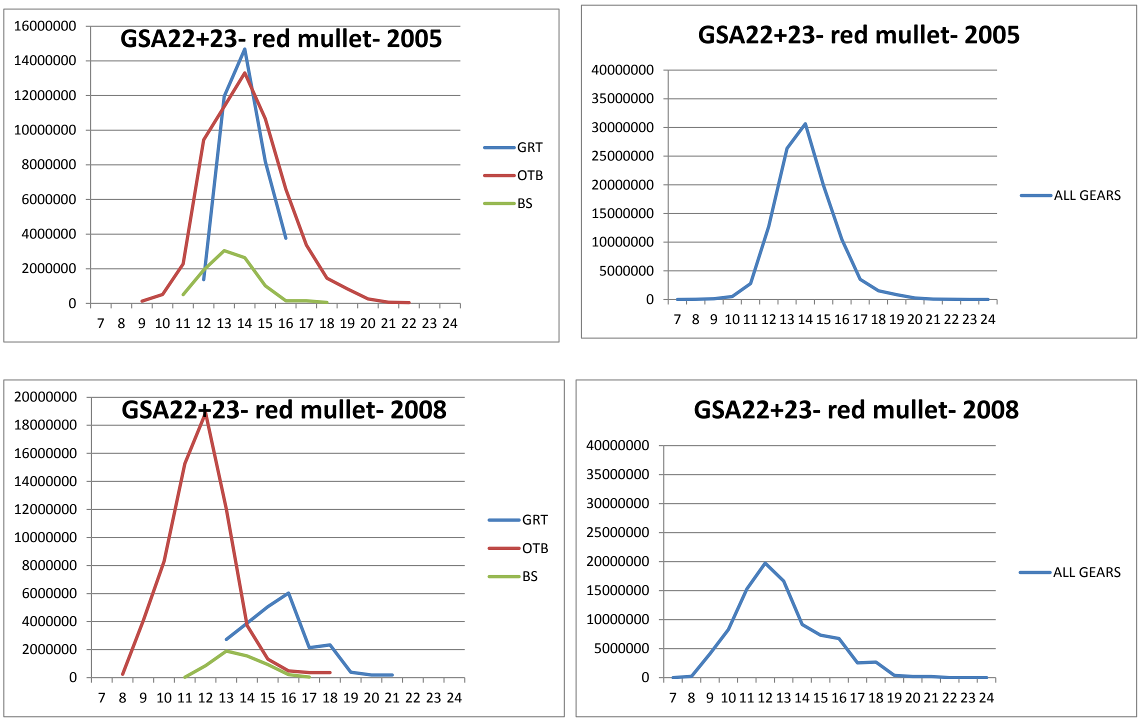



**Fig 1.10.2.2. *Mullus barbatus* annual landings by size and gear in GSA22&23 (DCR data). Data are shown only for 2005 and 2008 because in 2003, 2004 and 2004 no information on GRT sizes was provided (see "data quality and availability").**

***Discards***

No data on discards available from the DCR.

***Fishing effort***

The fishing effort for each year was reconstructed using several sources. Effort is expressed here as activity (number of days at sea) x overall HP corrected by a factor that takes into account the increased fishing power due to technological improvement (i.e. technological kreeping). A yearly increase in fishing efficiency was estimated to be of 2.72% (see Section 1 of this report for details).

### 1.10.3 *Scientific surveys*

#### 1.10.3.1 MEDITS

***Methods***

Based on the DCR data call, abundance and biomass indices were recalculated.

Data were assigned to bathymetric strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes trawling duration. Only hauls considered valid were used in the computations. Valid hauls include the cases of null catches of the species.

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma\ (Yi*Ai) / A$$

$$V(Yst) = \Sigma\ (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution and quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (sub-samples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

***Geographical distribution patterns***

Figure 1.10.3.3 provides the distribution of sampling hauls of the MEDITS survey in GSA 22&23.

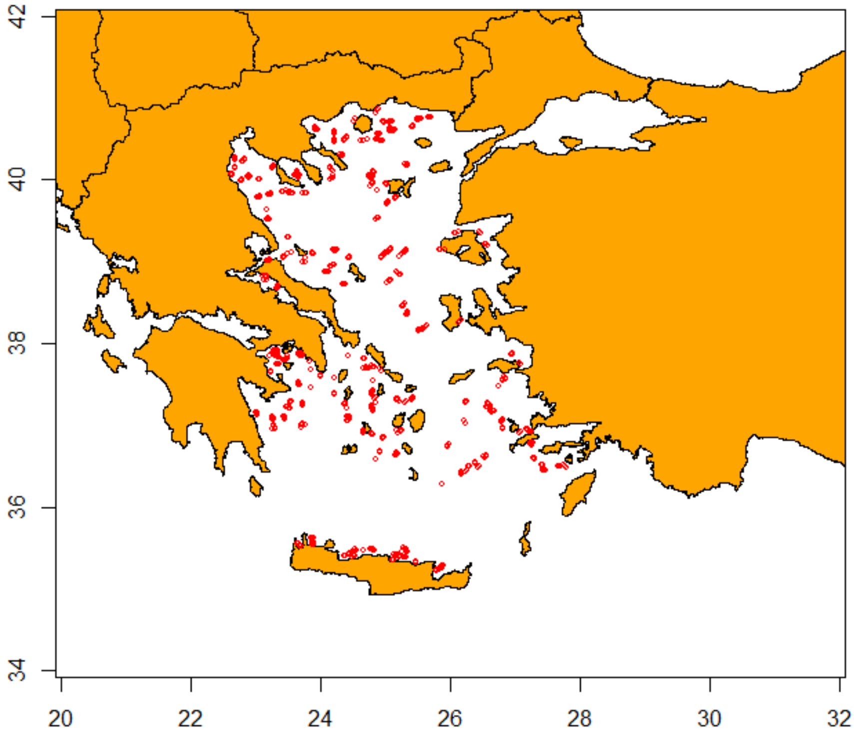



**Fig 1.10.3.3. Distribution of sampling hauls of the MEDITS survey in GSA 22&23.**

### *Trends in abundance and biomass*

Fishery independent information regarding the state of the red mullet in GSA 22&23 was derived from the international survey MEDITS. Figure 1.10.3.4 shows the estimated trend in biomass.

The estimated biomass index in GSA 22&23, displayed high fluctuations since 1994, with a peak in 1999 and low values in 2004-2006.

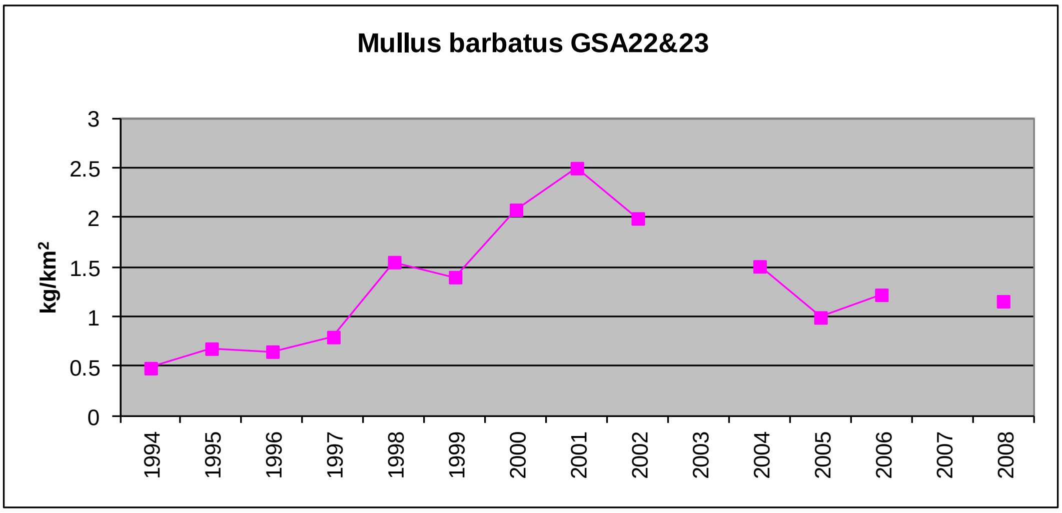



**Fig. 1.10.3.4. Trend in biomass (kg/km$^2$) of *Mullus barbatus* in GSA22&23 during 1994- 2008 (data source: MEDITS).**

***Trends in maturity***

No analyses were conducted.

1.10.4 *Assessment of historic stock parameters*

***Trends in growth***

No analyses were conducted

***Justification***

1.10.5 *Assessment of historic stock parameters*

Method 1: Length Cohort Analysis-VIT

***Justification***

Pseudocohort analysis was performed in GSA22&23 for 2005 and 2008 using VIT software (Lleonart and Salat, 1992) (see "Data quality and availability").

*Input parameters*

Analysis was performed using number at age obtained from length frequencies distribution separated by slicing method with VIT software. Input parameters (growth, natural mortality and maturity) are those given at the beginning of the assessment.

| GSA22- red mullet | | | | | | |
|---|---|---|---|---|---|---|
| TL | 2005 | 2005 | 2005 | 2008 | 2008 | 2008 |
| (cm) | GRT | OTB | BS | GRT | OTB | BS |
| 8 | 0 | 0 | 50671,35 | 0 | 240555,6 | 0 |
| 9 | 0 | 128765,9 | 0,01 | 0 | 4089445 | 0 |
| 10 | 0 | 515063,6 | 0,01 | 0 | 8299167 | 0 |
| 11 | 0 | 2277643 | 506713,5 | 0 | 15275278 | 24584,22 |
| 12 | 1365818 | 9438810 | 1925511 | 0 | 18883611 | 860447,5 |
| 13 | 11950911 | 11364742 | 3040281 | 2722868 | 12027778 | 1892985 |
| 14 | 14682548 | 13305930 | 2634910 | 3889812 | 3728611 | 1548806 |
| 15 | 8194911 | 10659121 | 1013427 | 5056755 | 1323056 | 934200,2 |
| 16 | 3756001 | 6593132 | 152014,1 | 6029208 | 481111,1 | 221257,9 |
| 17 | 0 | 3364864 | 152014,1 | 2139397 | 360833,3 | 49168,43 |
| 18 | 0 | 1456770 | 50671,35 | 2333887 | 360833,3 | 0 |
| 19 | 0 | 836334,1 | 0 | 388981,2 | 0 | 0 |
| 20 | 0 | 257531,8 | 0 | 194490,6 | 0 | 0 |
| 21 | 0 | 63738,63 | 0 | 194490,6 | 0 | 0 |
| 22 | 0 | 42921,97 | 0 | | | |

**Table 1.10.5.1. Input data for LCA. Catch at length in 2005 and 2008 in GSA22&23, by gear.**

***Results***

**2005**

| --- | Total | Gear 1 | Gear 2 | Gear 3 |
|---|---|---|---|---|
| Catch mean age | 1,239 | 1,249 | 1,24 | 1,183 |
| Catch mean length | 13,652 | 13,79 | 13,596 | 13,26 |
| Mean F | 1,04 | 0,352 | 0,614 | 0,074 |
| Total catch | 3097265,1 | 1402406 | 1423954 | 270905,2 |
| Spawning Stock Biomass, SSB | 1327927,7 | | | |
| Number of recruits, R | 343551,18 | | | |

**Table 1.10.5.2. Summary results of stock parameters derived from VIT model (Gear1= GTR; Gear2=OTB; Gear3=BS).**

| Catch in Numbers | | | | |
|---|---|---|---|---|
| Class | Total catch | Catch of gear 1 | Catch of gear 2 | Catch of gear 3 |
| 0 | 4721,78 | 271,35 | 3539,56 | 910,87 |
| 1 | 99109,42 | 48012,75 | 42128,91 | 8967,76 |
| 2 | 2067,31 | 0 | 2016,85 | 50,47 |
| 3 | 34,67 | 0 | 34,67 | 0 |

**Table 1.10.5.3. Catch at age calculated by slicing method with VIT software model (Gear1= GTR; Gear2=OTB; Gear3=BS).**

| VPA Results--Numbers | |
|---|---|
| Class | Initial number |
| 0 | 343551,18 |
| 1 | 123642,39 |
| 2 | 3692,89 |
| 3 | 669,5 |

**Table 1.10.5.4. LCA output. Stock numbers at age.**

| Class | Total F | F of gear 1 | F of gear 2 | F of gear 3 |
|---|---|---|---|---|
| 0 | 0,022 | 0,001 | 0,016 | 0,004 |
| 1 | 2,901 | 1,405 | 1,233 | 0,262 |
| 2 | 1,168 | 0 | 1,139 | 0,029 |
| 3 | 0,068 | 0 | 0,068 | 0 |
| Mean Mort. rates | 1,04 | 0,352 | 0,614 | 0,074 |

**Tab. 1.10.5.5. LCA output. Fishing mortality by age and model (Gear1= GTR; Gear2=OTB; Gear3=BS).**

**2008**

| --- | Total | Gear 1 | Gear 2 | Gear 3 |
|---|---|---|---|---|
| Catch mean age | 1,057 | 1,474 | 0,896 | 1,304 |
| Catch mean length | 12,109 | 15,025 | 10,958 | 14,089 |
| Mean F | 0,556 | 0,236 | 0,283 | 0,037 |
| Total catch | 2415443,15 | 894326,7 | 1333262 | 187854 |

| | |
|---|---|
| Spawning Stock Biomass, SSB | 2334891,84 |
| Number of recruits, R | 306666,83 |

**Table 1.10.5.6. Summary results of stock parameters derived from VIT model (Gear1= GTR; Gear2=OTB; Gear3=BS).**

| Catch in Numbers | | | | |
|---|---|---|---|---|
| Class | Total catch | Catch of gear 1 | Catch of gear 2 | Catch of gear 3 |
| 0 | 32156,52 | 0 | 31979,19 | 177,33 |
| 1 | 60029,53 | 19526,76 | 34772,24 | 5730,53 |
| 2 | 3298,48 | 2942,88 | 355,59 | 0 |
| 3 | 2,68 | 2,68 | 0 | 0 |
| Total | 95487,2 | 22472,32 | 67107,03 | 5907,86 |
| Mean Age | 1,057 | 1,474 | 0,896 | 1,304 |
| Mean Len | 12,109 | 15,025 | 10,958 | 14,089 |

**Table 1.10.5.7. Catch at age calculated by slicing method with VIT software model (Gear1= GTR; Gear2=OTB; Gear3=BS).**

| VPA Results--Numbers | |
|---|---|
| Class | Initial number |
| 0 | 306666,83 |
| 1 | 94372,63 |
| 2 | 10814,78 |
| 3 | 3867,89 |

**Table 1.10.5.8. LCA output. Stock numbers at age.**

| VPA Results--Mortalities | | | | |
|---|---|---|---|---|
| Class | Total F | F of gear 1 | F of gear 2 | F of gear 3 |
| 0 | 0,179 | 0 | 0,178 | 0,001 |
| 1 | 1,556 | 0,506 | 0,902 | 0,149 |
| 2 | 0,488 | 0,436 | 0,053 | 0 |
| 3 | 0,001 | 0,001 | 0 | 0 |
| Mean Mort. rates | 0,556 | 0,236 | 0,283 | 0,037 |

**Tab. 1.10.5.9. LCA output. Fishing mortality by age and model (Gear1= GTR; Gear2=OTB; Gear3=BS).**

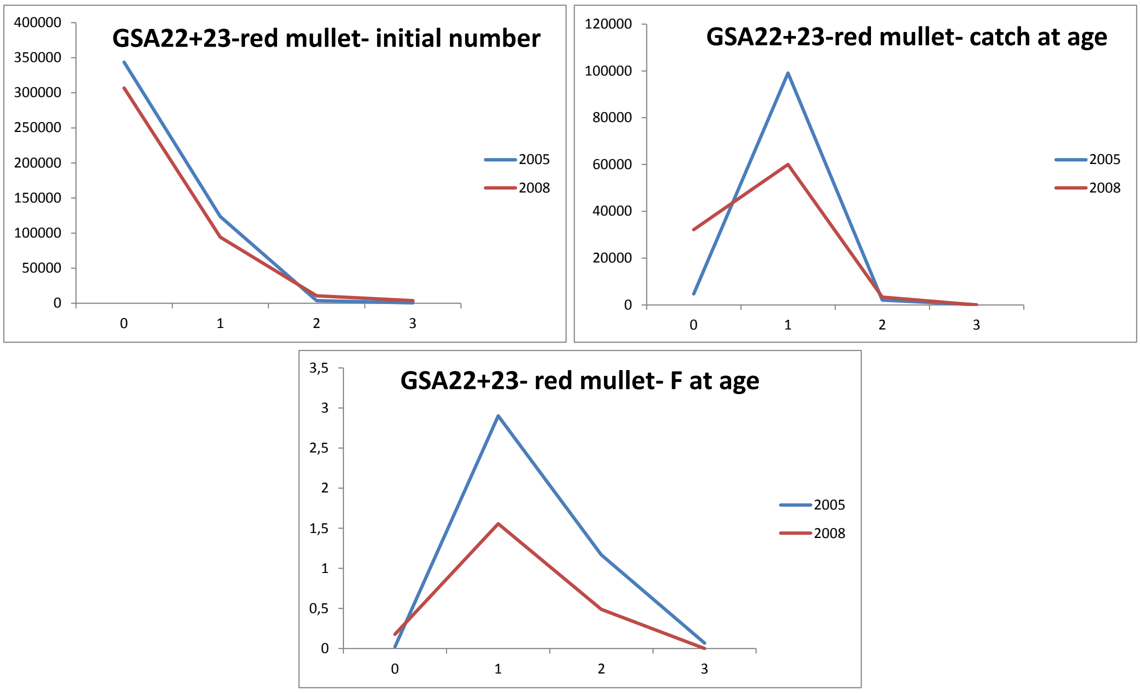



**Fig 1.10.5.5. Red mullet in GSA22&23. LCA results, initial number and catch and F at age in 2005 and 2008 (all gears combined). The main component of landings is by far age class 1.**

**Yield per recruit analysis results**

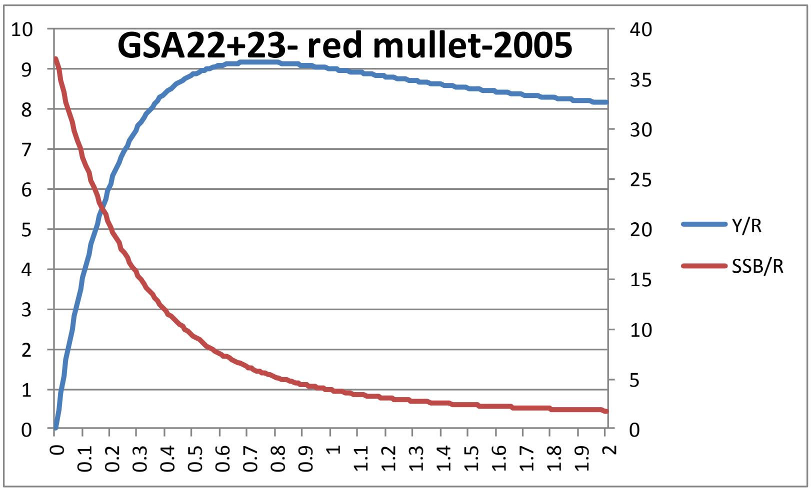
YPR analysis was performed using as input the output of the LCA by ages.

| ___ | Factor | Y/R | B/R | SSB | Y/R Gear 1 | Y/R Gear 2 | Y/R Gear 3 |
|---|---|---|---|---|---|---|---|
| F(0) | 0 | 0 | 40,874 | 37,12 | 0 | 0 | 0 |
| F(0.1) | 0,53 | 8,956 | 11,992 | 8,705 | 3,642 | 4,594 | 0,721 |
| Max Gear2 | 0,53 | 8,93 | 12,193 | 8,901 | 3,619 | 4,595 | 0,717 |
| Max(:) | 0,74 | 9,176 | 9,031 | 5,836 | 3,954 | 4,451 | 0,771 |
| phi=1 | 1,01 | 9,015 | 6,973 | 3,865 | 4,082 | 4,145 | 0,789 |
| Max Gear3 | 1,03 | 8,996 | 6,871 | 3,769 | 4,084 | 4,123 | 0,789 |
| Max Gear1 | 1,09 | 8,936 | 6,593 | 3,506 | 4,086 | 4,062 | 0,788 |
| phi=2 | 2 | 8,157 | 4,767 | 1,823 | 3,871 | 3,535 | 0,751 |

**Tab. 1.10.5.10. 2005. Results of the YPR analysis (Gear1= OTB; Gear2=GTR).**

| ___ | Factor | Y/R | B/R | SSB | Y/R Gear 1 | Y/R Gear 2 | Y/R Gear 3 |
|---|---|---|---|---|---|---|---|
| F(0) | 0 | 0 | 40,874 | 37,12 | 0 | 0 | 0 |
| Max Gear1 | 0,82 | 7,648 | 12,946 | 9,909 | 2,967 | 4,098 | 0,583 |
| F(0.1) | 0,88 | 7,761 | 11,964 | 8,972 | 2,959 | 4,206 | 0,597 |
| phi=1 | 1,01 | 7,876 | 10,534 | 7,614 | 2,916 | 4,348 | 0,613 |
| Max(:) | 1,15 | 7,918 | 9,194 | 6,352 | 2,837 | 4,459 | 0,622 |
| Max Gear3 | 1,29 | 7,889 | 8,128 | 5,359 | 2,739 | 4,525 | 0,625 |
| Max Gear2 | 1,56 | 7,715 | 6,627 | 3,985 | 2,531 | 4,567 | 0,617 |
| phi=2 | 2 | 7,283 | 5,112 | 2,65 | 2,202 | 4,5 | 0,582 |

**Table 1.10.5.11. 2008. Results of the YPR (Gear1= GTR; Gear2=OTB; Gear3=BS).**



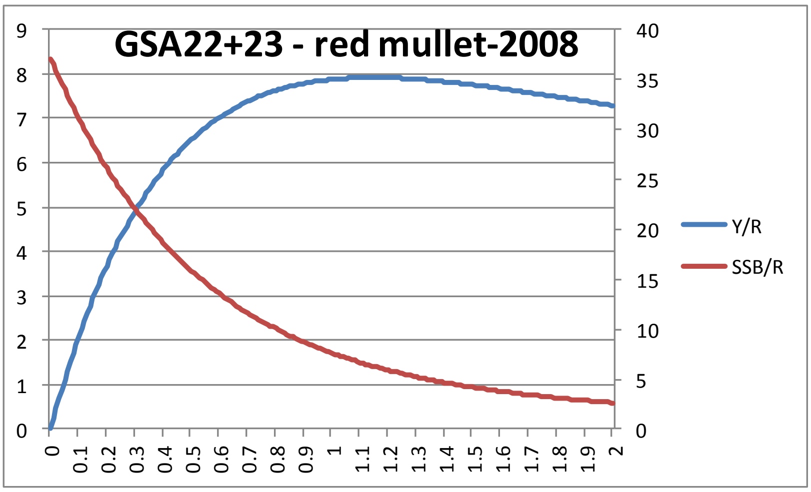




**Fig. 1.10.5.6. YPR outputs. YPR (left axis) and SSB/R (right axis), in grams, for red mullet in GSA 22&23 in 2005 and 2008. Note that x- axis indicates factor (not F value).**

| **2005** | | | **2008** | | |
|---|---|---|---|---|---|
| Factor | | | Factor | | |
| 0.53 | F(0.1) | 0.551 | 0.88 | F(0.1) | 0.489 |
| 0.74 | Fmax | 0.770 | 1.15 | Fmax | 0.639 |
| 1.01 | Fcurrent | 1.040 | 1.01 | Fcurrent | 0.556 |

**Table 1.10.5.12. YPR outputs. $F_{(0,1)}$ and $F_{max}$ calculated from $F_{(0,1)}$ and $F_{max}$ factors and $F_{current}$.**

F=0.52 is proposed as proxy of $F_{MSY}$ for this stock (average of $F_{01}$ in 2005 and 2008). According to the F estimates derived from LCA, F in 2005 and 2008 was larger than $F_{MSY}$. Based on this assessment, the stock of red mullet in GSA22&23 was exploited unsustainably.

**Data quality and availability**

Data used in the LCA were taken from the access database "SGMED 2009 fisheries data 20100118GRConly". A number of gaps and inconsistencies were found in the DCR Fisheries data, which determined the years that could be used as input for LCA. The main problem is that landings data by gear taken from the database or calculated from the size distributions by gear are rather different, due to the lack of data on sizes. Taking into account that only in 2005 and 2008 sizes were available for OTB and GTR, these years was chosen as input for LCA. No data on discards available and no data for 2007.

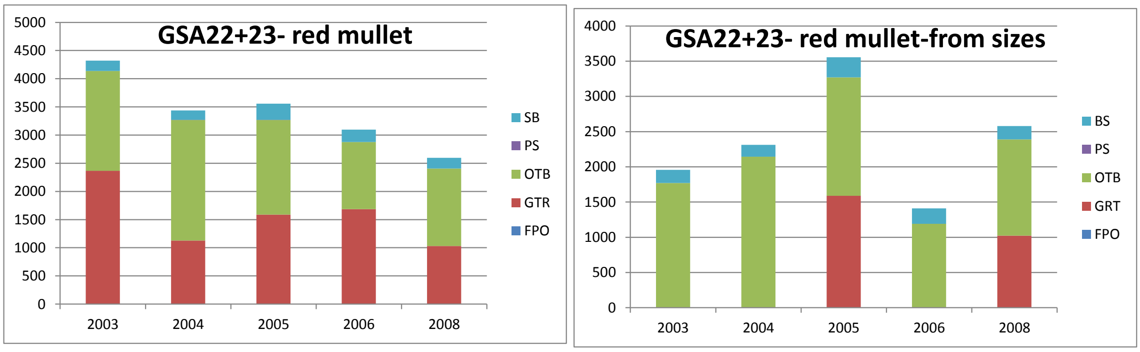



**Fig. 1.10.5.7. Red mullet annual landings (t) in GSA22&23, as taken from the access database (left) and calculated from the annual size distributions by gear (right).**

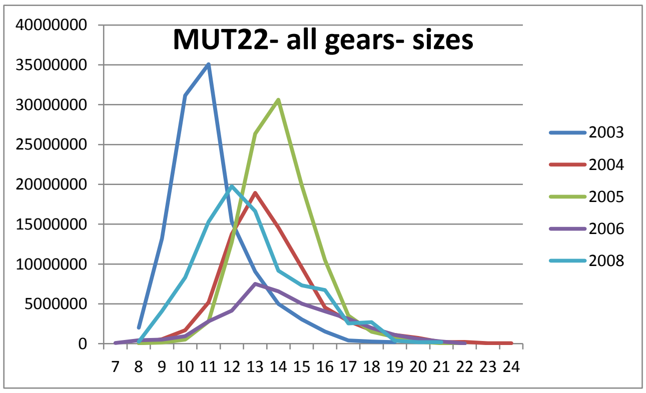



**Fig. 1.10.5.8. Red mullet annual size distributions (numbers) in GSA20 (data source: access database).**

### 1.10.5.1 Method 2: Stock-Production model

***Justification***

The analysis was performed using the ASPIC.5 software (A Stock-Production model Incorporating Covariates) (Prager, 1994, 2005) assuming a Schaefer (1954) model. This program implements a non-equilibrium, continuous-time, observation-error estimator for the dynamic production model (Schnute, 1977; Prager, 1994). The model was used to estimate *r* (the intrinsic rate of population growth), *MSY*, the ratios of both current biomass or *F* to the biomass or F at which *MSY* can be attained, and *q* (the catchability coefficient, the proportion of total stock removed by one unit of fishing effort).

*Input parameters*

Input data consist in 4 sets of time series from 1964 to 2007 of total landings (in tons) and fishing effort expressed as days fishing x HP. Data regards landings and effort related to trawling, purse seining, beach seines and other small scale fisheries mostly including set nets. No information was available in order to determine more detailed specific effort targeting the stock in question between each fishing strategy and hence for the analysis it was assumed that neither targets for each fishing technique nor areas did change along the studied period.

MEDITS trawls surveys estimates of the index of abundance between 1994 and 2008 were available but the series was incomplete, very short and showing high fluctuating values and hence such information was not included in this analysis. For this reason, no analysis based on survey data was performed even though an attempt of including such information in the analysis was done. Such attempt resulted unsuccessful because lacking of enough correlation with the CPUE's time series.

Considering the lower importance of beach seines and purse seines in the overall catch and also that the stocks in question were not the target of such fisheries, a lower weight were assigned to the information proceeding from such fisheries for the computations. As a setting option of ASPIC, priority (more weight) was assigned to the information on landings than to effort, considered the last measured with lower precision.

Several models were tested (Schaefer, Fox, Generalized), but the only that supplied fairly good fittings and reasonable results was the logistic Schaefer model. From the bootstrap results, bias-corrected (BC) confidence intervals were computed by standard methods (Efron and Gong 1983). 1000 bootstrap trials were performed computing 90% confidence intervals.

**Table 1.10.5.13. ASPIC input parameters of the FIT mode for GSA 22 & 23.**

| **B1/K** | **MSY** | **Range of MSY** | **K** | **Range of K** | **Fishing fleet** | **q (mean (CPUE) / 2*max(Y))** |
|---|---|---|---|---|---|---|
| 0.5 | 4.00E+2 | 3.00E+02 to 1.50E+03 | 1.300E+03 | 8.00E+02 to 1.200E+04 | Trawlers<br>Purse seine<br>Beach seine<br>Small scale | 3.364E-08<br>3.775E-08<br>3.178E-08<br>4.522E-08 |

*Results*

Mullus barbatus GSA 22-23
MANAGEMENT and DERIVED PARAMETER ESTIMATES

```
------------------------------------------------------------------------------------------------------------------
Parameter                                   Estimate          Logistic formula        General formula
MSY      Maximum sustainable yield            2442                  ----                   ----
Bmsy     Stock biomass giving MSY             7919                  K/2          K*n**(1/(1-n))
Fmsy     Fishing mortality rate at MSY       0. 3083             MSY/Bmsy              MSY/Bmsy
B./Bmsy  Ratio: B(2008)/Bmsy                8.906E-01               ----                 ----
F./Fmsy  Ratio: F(2007)/Fmsy                1.181E+00               ----                 ----
Ye.      Equilibrium yield available in 2008     2.413E+03     4*MSY*(B/K-(B/K)**2)     g*MSY*(B/K-(B/K)**n)      ...as proportion of
MSY               9.880E-01

CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)
------------------------------------------------------------------------------------------------------------------
                              |
 1  trawlers                  |  1.000
```

| 44
|
2 purse seine | 0.773 1.000
| 44 44
|
3 beach seine | 0.285 0.161 1.000
| 44 44 44
|
4 small scale | 0.748 0.547 0.062 1.000
| 44 44 44 44
--------------------------------------------------
1 2 3 4

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

| Obs | Year or ID | Estimated total F mort | Estimated starting biomass | Estimated average biomass | Observed total yield | Model total yield | Estimated surplus production | Ratio of F mort to Fmsy | -Ratio of biomass to Bmsy |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1964 | 0.034 | 2.414E+04 | 2.111E+04 | 7.257E+02 | 7.257E+02 | -4.421E+03 | 1.115E-01 | 3.048E+00 |
| 2 | 1965 | 0.044 | 1.899E+04 | 1.778E+04 | 7.765E+02 | 7.765E+02 | -1.359E+03 | 1.416E-01 | 2.398E+00 |
| 3 | 1966 | 0.051 | 1.686E+04 | 1.625E+04 | 8.305E+02 | 8.305E+02 | -2.619E+02 | 1.658E-01 | 2.128E+00 |
| 4 | 1967 | 0.047 | 1.576E+04 | 1.548E+04 | 7.263E+02 | 7.263E+02 | 2.148E+02 | 1.522E-01 | 1.991E+00 |
| 5 | 1968 | 0.061 | 1.525E+04 | 1.501E+04 | 9.174E+02 | 9.174E+02 | 4.823E+02 | 1.982E-01 | 1.926E+00 |
| 6 | 1969 | 0.060 | 1.482E+04 | 1.469E+04 | 8.878E+02 | 8.878E+02 | 6.567E+02 | 1.960E-01 | 1.871E+00 |
| 7 | 1970 | 0.073 | 1.459E+04 | 1.444E+04 | 1.051E+03 | 1.051E+03 | 7.857E+02 | 2.359E-01 | 1.842E+00 |
| 8 | 1971 | 0.083 | 1.432E+04 | 1.418E+04 | 1.172E+03 | 1.172E+03 | 9.152E+02 | 2.681E-01 | 1.808E+00 |
| 9 | 1972 | 0.070 | 1.406E+04 | 1.406E+04 | 9.890E+02 | 9.890E+02 | 9.752E+02 | 2.282E-01 | 1.776E+00 |
| 10 | 1973 | 0.075 | 1.405E+04 | 1.402E+04 | 1.048E+03 | 1.048E+03 | 9.927E+02 | 2.425E-01 | 1.774E+00 |
| 11 | 1974 | 0.086 | 1.399E+04 | 1.391E+04 | 1.192E+03 | 1.192E+03 | 1.043E+03 | 2.778E-01 | 1.767E+00 |
| 12 | 1975 | 0.091 | 1.384E+04 | 1.377E+04 | 1.252E+03 | 1.252E+03 | 1.110E+03 | 2.948E-01 | 1.748E+00 |
| 13 | 1976 | 0.091 | 1.370E+04 | 1.366E+04 | 1.246E+03 | 1.246E+03 | 1.160E+03 | 2.958E-01 | 1.730E+00 |
| 14 | 1977 | 0.088 | 1.362E+04 | 1.361E+04 | 1.200E+03 | 1.200E+03 | 1.182E+03 | 2.860E-01 | 1.720E+00 |
| 15 | 1978 | 0.102 | 1.360E+04 | 1.351E+04 | 1.381E+03 | 1.381E+03 | 1.223E+03 | 3.314E-01 | 1.717E+00 |
| 16 | 1979 | 0.101 | 1.344E+04 | 1.340E+04 | 1.351E+03 | 1.351E+03 | 1.273E+03 | 3.270E-01 | 1.697E+00 |
| 17 | 1980 | 0.098 | 1.336E+04 | 1.335E+04 | 1.306E+03 | 1.306E+03 | 1.291E+03 | 3.172E-01 | 1.687E+00 |
| 18 | 1981 | 0.094 | 1.335E+04 | 1.337E+04 | 1.252E+03 | 1.252E+03 | 1.286E+03 | 3.038E-01 | 1.686E+00 |
| 19 | 1982 | 0.103 | 1.338E+04 | 1.334E+04 | 1.373E+03 | 1.373E+03 | 1.297E+03 | 3.339E-01 | 1.690E+00 |
| 20 | 1983 | 0.110 | 1.331E+04 | 1.324E+04 | 1.459E+03 | 1.459E+03 | 1.339E+03 | 3.575E-01 | 1.680E+00 |
| 21 | 1984 | 0.154 | 1.319E+04 | 1.291E+04 | 1.986E+03 | 1.986E+03 | 1.473E+03 | 4.992E-01 | 1.665E+00 |
| 22 | 1985 | 0.169 | 1.267E+04 | 1.243E+04 | 2.104E+03 | 2.104E+03 | 1.650E+03 | 5.492E-01 | 1.600E+00 |
| 23 | 1986 | 0.235 | 1.222E+04 | 1.174E+04 | 2.757E+03 | 2.757E+03 | 1.872E+03 | 7.617E-01 | 1.543E+00 |
| 24 | 1987 | 0.180 | 1.133E+04 | 1.131E+04 | 2.038E+03 | 2.038E+03 | 1.994E+03 | 5.845E-01 | 1.431E+00 |
| 25 | 1988 | 0.219 | 1.129E+04 | 1.109E+04 | 2.428E+03 | 2.428E+03 | 2.051E+03 | 7.104E-01 | 1.426E+00 |
| 26 | 1989 | 0.242 | 1.091E+04 | 1.068E+04 | 2.579E+03 | 2.579E+03 | 2.145E+03 | 7.834E-01 | 1.378E+00 |
| 27 | 1990 | 0.280 | 1.048E+04 | 1.015E+04 | 2.847E+03 | 2.847E+03 | 2.246E+03 | 9.095E-01 | 1.323E+00 |
| 28 | 1991 | 0.355 | 9.876E+03 | 9.355E+03 | 3.325E+03 | 3.325E+03 | 2.358E+03 | 1.153E+00 | 1.247E+00 |
| 29 | 1992 | 0.292 | 8.909E+03 | 8.822E+03 | 2.573E+03 | 2.573E+03 | 2.410E+03 | 9.460E-01 | 1.125E+00 |
| 30 | 1993 | 0.301 | 8.745E+03 | 8.647E+03 | 2.605E+03 | 2.605E+03 | 2.421E+03 | 9.771E-01 | 1.104E+00 |
| 31 | 1994 | 0.350 | 8.561E+03 | 8.309E+03 | 2.909E+03 | 2.909E+03 | 2.435E+03 | 1.136E+00 | 1.081E+00 |
| 32 | 1995 | 0.409 | 8.087E+03 | 7.705E+03 | 3.154E+03 | 3.154E+03 | 2.438E+03 | 1.327E+00 | 1.021E+00 |
| 33 | 1996 | 0.414 | 7.371E+03 | 7.095E+03 | 2.937E+03 | 2.937E+03 | 2.414E+03 | 1.342E+00 | 9.308E-01 |
| 34 | 1997 | 0.438 | 6.849E+03 | 6.578E+03 | 2.884E+03 | 2.884E+03 | 2.371E+03 | 1.422E+00 | 8.649E-01 |
| 35 | 1998 | 0.364 | 6.335E+03 | 6.354E+03 | 2.310E+03 | 2.310E+03 | 2.346E+03 | 1.179E+00 | 8.000E-01 |
| 36 | 1999 | 0.358 | 6.372E+03 | 6.403E+03 | 2.292E+03 | 2.292E+03 | 2.352E+03 | 1.161E+00 | 8.046E-01 |
| 37 | 2000 | 0.367 | 6.432E+03 | 6.429E+03 | 2.360E+03 | 2.360E+03 | 2.355E+03 | 1.191E+00 | 8.122E-01 |
| 38 | 2001 | 0.317 | 6.427E+03 | 6.576E+03 | 2.082E+03 | 2.082E+03 | 2.371E+03 | 1.027E+00 | 8.115E-01 |
| 39 | 2002 | 0.310 | 6.716E+03 | 6.858E+03 | 2.125E+03 | 2.125E+03 | 2.398E+03 | 1.005E+00 | 8.481E-01 |
| 40 | 2003 | 0.286 | 6.989E+03 | 7.181E+03 | 2.050E+03 | 2.050E+03 | 2.420E+03 | 9.261E-01 | 8.826E-01 |
| 41 | 2004 | 0.299 | 7.358E+03 | 7.465E+03 | 2.229E+03 | 2.229E+03 | 2.434E+03 | 9.682E-01 | 9.292E-01 |
| 42 | 2005 | 0.318 | 7.563E+03 | 7.578E+03 | 2.409E+03 | 2.409E+03 | 2.437E+03 | 1.031E+00 | 9.551E-01 |
| 43 | 2006 | 0.377 | 7.591E+03 | 7.403E+03 | 2.788E+03 | 2.788E+03 | 2.431E+03 | 1.221E+00 | 9.586E-01 |
| 44 | 2007 | 0.364 | 7.234E+03 | 7.139E+03 | 2.599E+03 | 2.599E+03 | 2.418E+03 | 1.181E+00 | 9.136E-01 |
| 45 | 2008 | | 7.053E+03 | | | | | | |

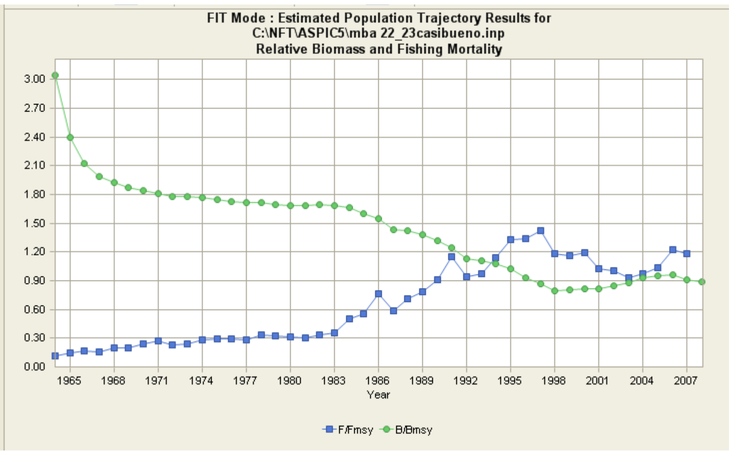



**Fig. 1.10.5.9. F/F$_{MSY}$ and B/B$_{MSY}$ estimated for each year.**

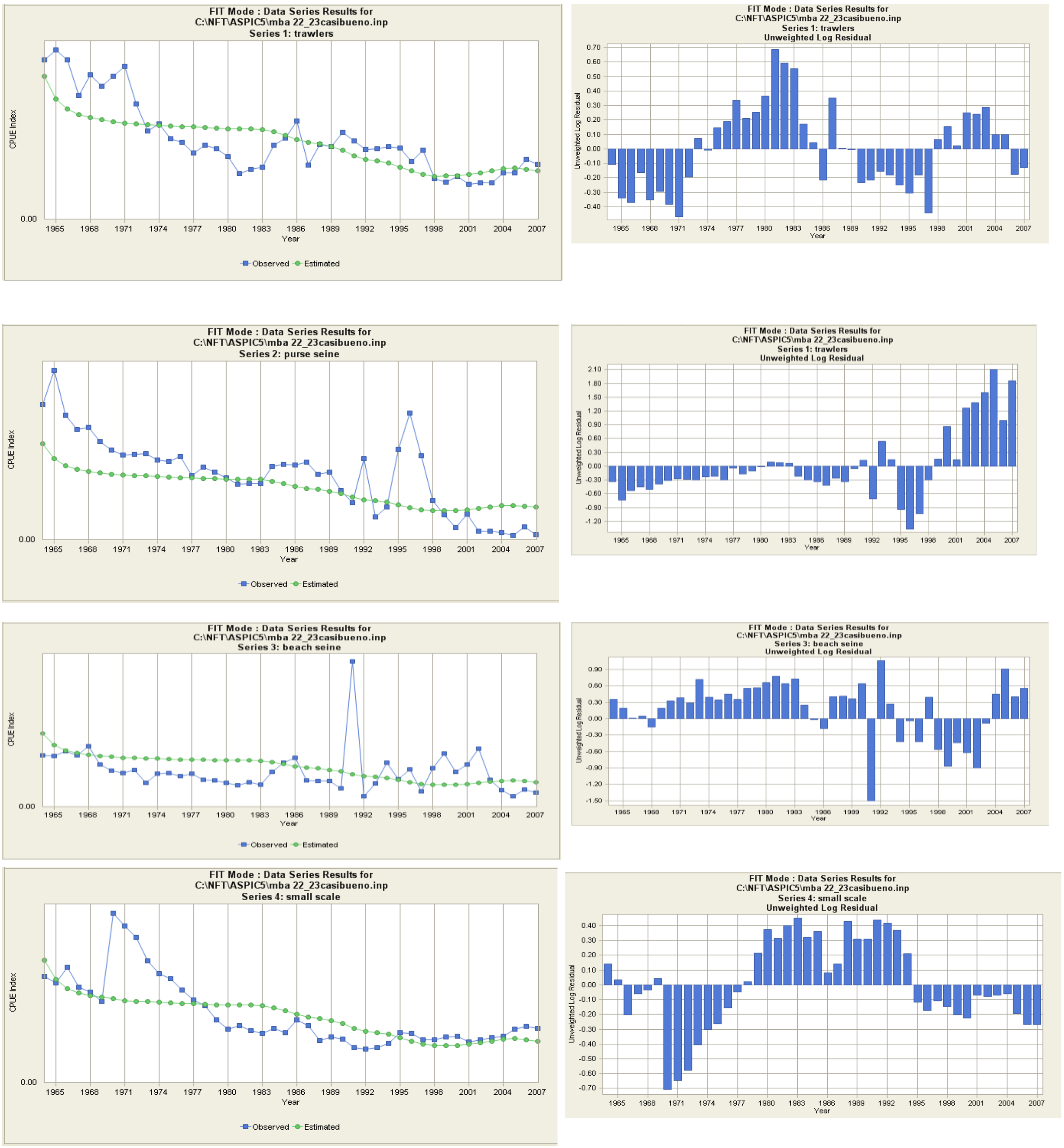



**Fig. 1.9.5.10. Model fitting for each gear/strategy and residuals.**

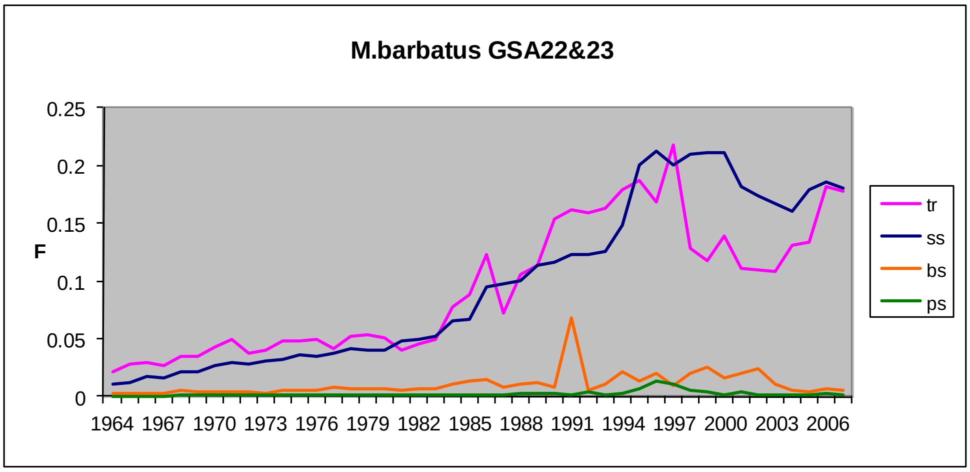



**Fig. 1.10.5.11. F vector by gear for *Mullus barbatus* in GSA22&23 (tr (trawlers), ss (small-scale) bs (beach seines), ps (purse seiners).**

The results of the ASPIC runs are presented in Figures 1.10.5.9-11. The stock of red mullet in GSA22&23 in 2007 can be considered overexploited (current $F_{curr}/F_{MSY}$=1.18 and the current biomass is below $B_{MSY}$ ($B/B_{MSY}$ = 0.91). Data of abundance index from MEDITS have also shown a lower correlation with commercial data. The catch and effort data sets for purse seine and beach seine have shown a lower correlation, probably because in these fisheries the species is not a priority commercial species. Moreover, the landings of these two gears are almost negligible. A value of $F_{MSY}$ of 0.308 was estimated while the model estimated for the more recent year (2007) a value of $F$ of about 0.32.

**Data quality and availability**

Data used in ASPIC proceed from a reconstruction of landings derived from different sources. A number of gaps and inconsistencies can be found. The main problems regard the quality of effort information, which regards the total effort by type of gear or group of gears without distinction on the metier. For species that shows a limited bathymetric distribution as *Mullus barbatus*, the lack of such information does not allow to quantify which is the correct amount of effort directed to the species in question, having the bathymetric distribution of some fleets (i.e. trawlers) more wide depth range. Moreover, no data on discards is available.

This lack of information obliged to assume that the pattern of spatial distribution and target of the fleets remained almost unchanged along the analysed period and also the discards rate. Only in this way it is possible to assume that the observed changes in abundance (CPUE) are mainly due to changes in fishing pressure on the stock in question.

### 1.10.5.2 Method 3: SURBA (Survey Based Assessment)

***Justification***

The relatively long time series of data available from the MEDITS surveys provided the most useful data set to analyse the trend of *Mullus barbatus* stock in GSAs 22&23. The MEDITS indices of abundance (n/hour) for red mullet in GSA 22-23, covering the period 1994-2008 (except years 2002 and 2007) were analysed using SURBA (Survey-Based stock Assessment approach, Needle, 2003). The annual standardized size distributions (1 cm total length class, Fig. 1.10.5.12) from MEDITS were converted in age distributions using L2AGE4 software (Fig. 1.10.5.13).

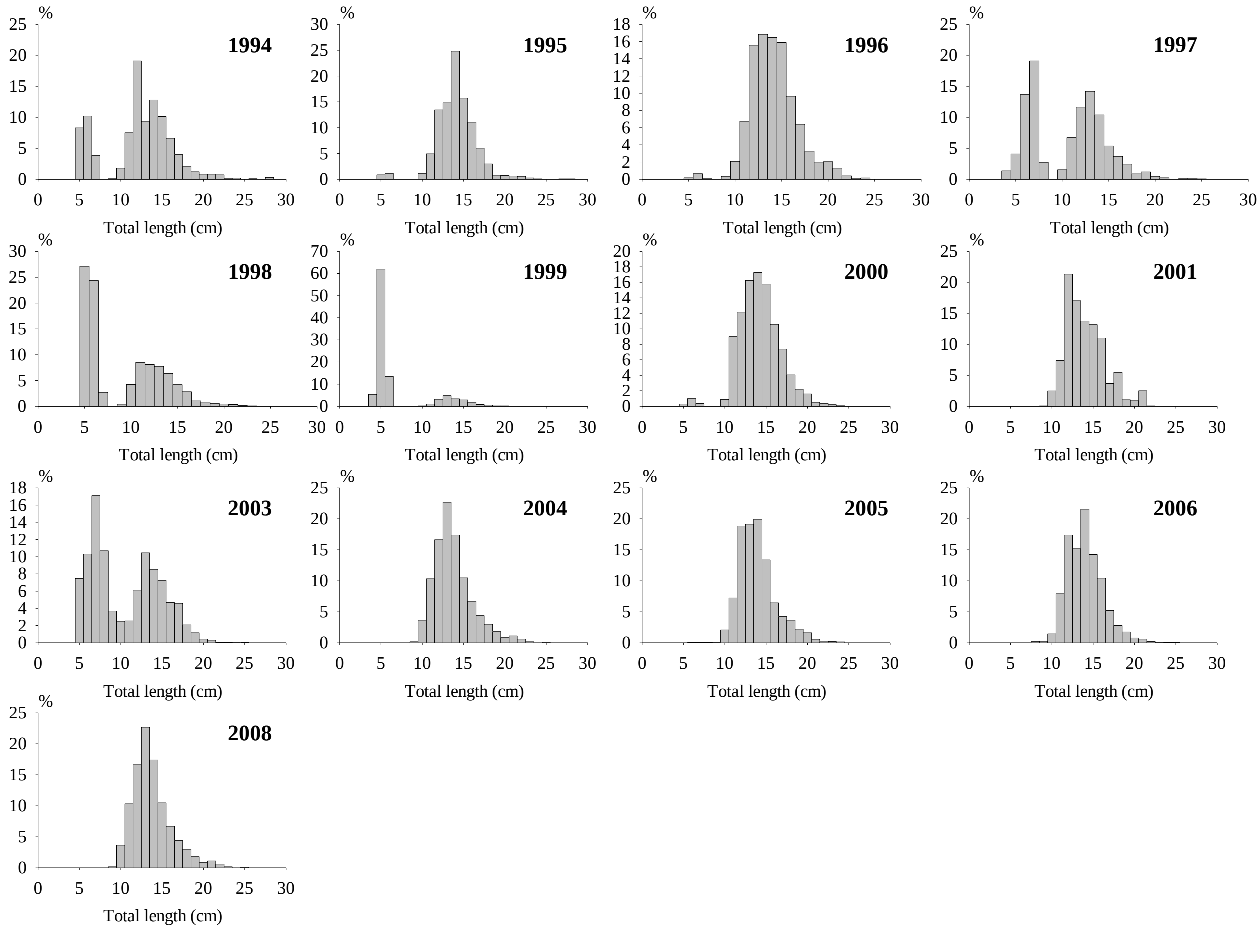



**Fig. 1.10.5.12. MEDITS length frequency distributions of red mullet in the GSAs 22&23.**

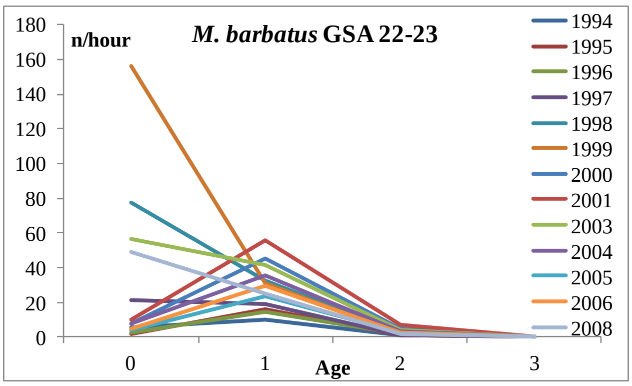



**Fig. 1.10.5.13. Numbers at age distributions of red mullet from MEDITS 1994-2008 in GSAs 22&23.**

***Input parameters***

Single survey exploratory SURBA 2.2 model runs were carried out fitting constant catchability (1.0 for all ages)

The model settings are given below:
Year range: 1994-2008, 2002 and 2007 lacking
Age range: 0-3+
Age weighting: 0.8 (ages 0), 1 (ages 1), 0.60 (age 2-3)

Growth, maturity and natural mortality input parameters of SURBA are those indicated at the beginning of the assessment.

***Results***

Comparative scatterplots at age indicated a poor consistency of the MEDITS data, between all ages 0-3 but quite good for the other combinations (Fig. 1.10.5.14).

The trends in F, SSB and recruitment at age 0 from SURBA run, and the model residuals are given in Figures 1.10.5.15-16. The retrospectives for the MEDITS survey data are given in Figure 1.10.5.17.

SURBA estimated large oscillations in the temporal effect for F. The age effect showed the highest values for ages 2 and 3+. The cohort effect indicated certain increase in the recruitment. Total mortality (Z) showed oscillations, with abnormal values for 2007. F (bootstrapped estimates) also showed some oscillations. SSB showed oscillations, with maximum values in 2000 and 2007. The residuals at age did not show any pattern.

The SURBA assessment generally cannot be considered reliable since age cohorts present a poor fit, estimated index for F, SSB and recruitment are highly irregular. In addition the analysis is largely driven by the selected catchability pattern.

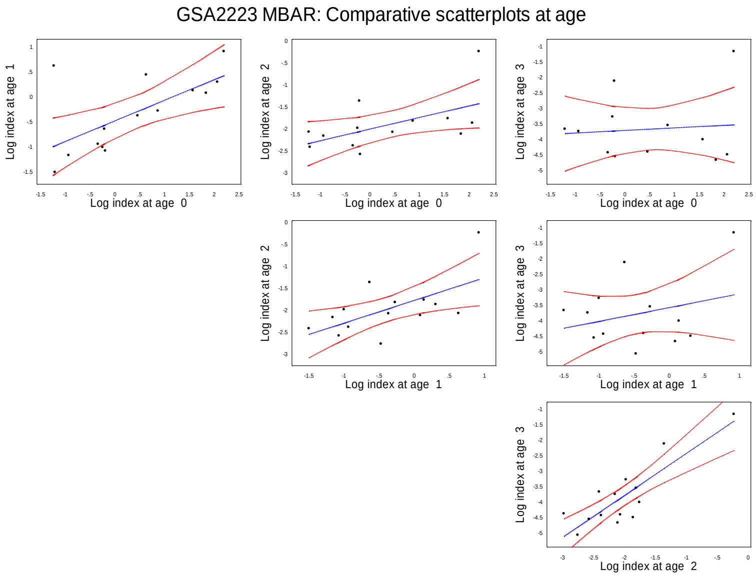
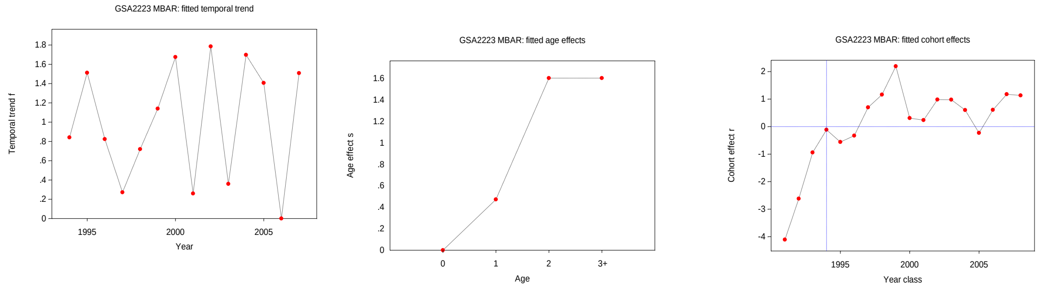
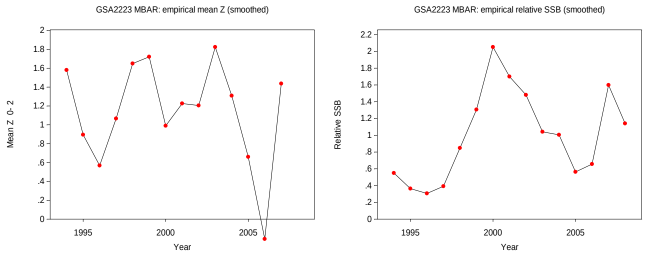



**Fig. 1.10.5.14. Red mullet in GSAs 22&23: Output from SURBA plots for MEDITS survey, showing age scatter plots.**

A)




B)




C)

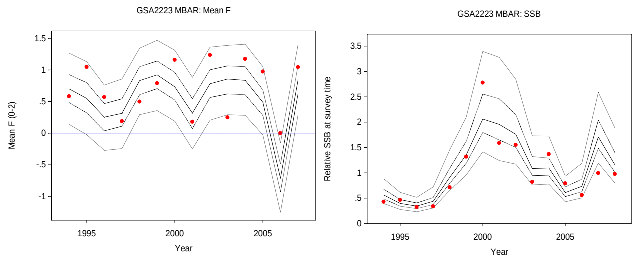
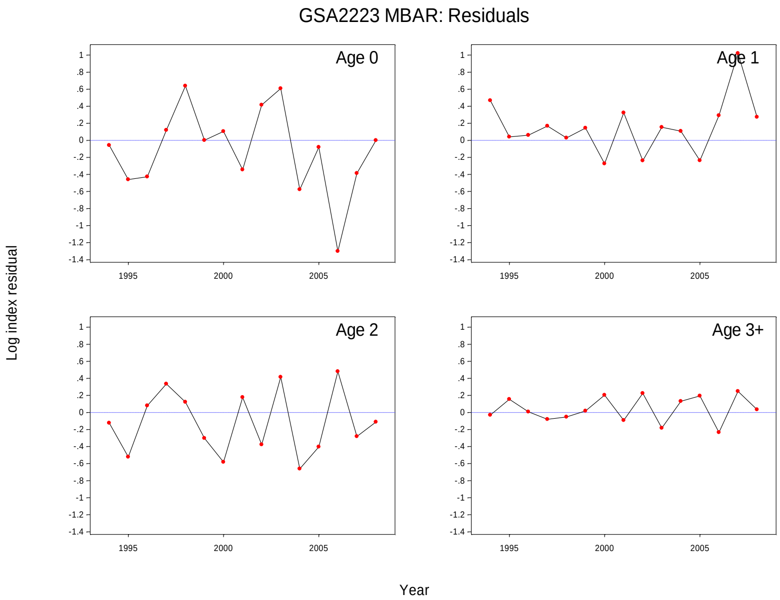



**Fig. 1.10.5.15. SURBA estimates for red mullet in GSAs 22&23. A) model parameters. B) total mortality and SSB C) bootstrapped (lines) and fitted (points) estimates of F and SSB, and empirical relative SSB, solid and dotted lines are respectively 50% and 5- 95% of bootstrapped estimates.**

A)



B)

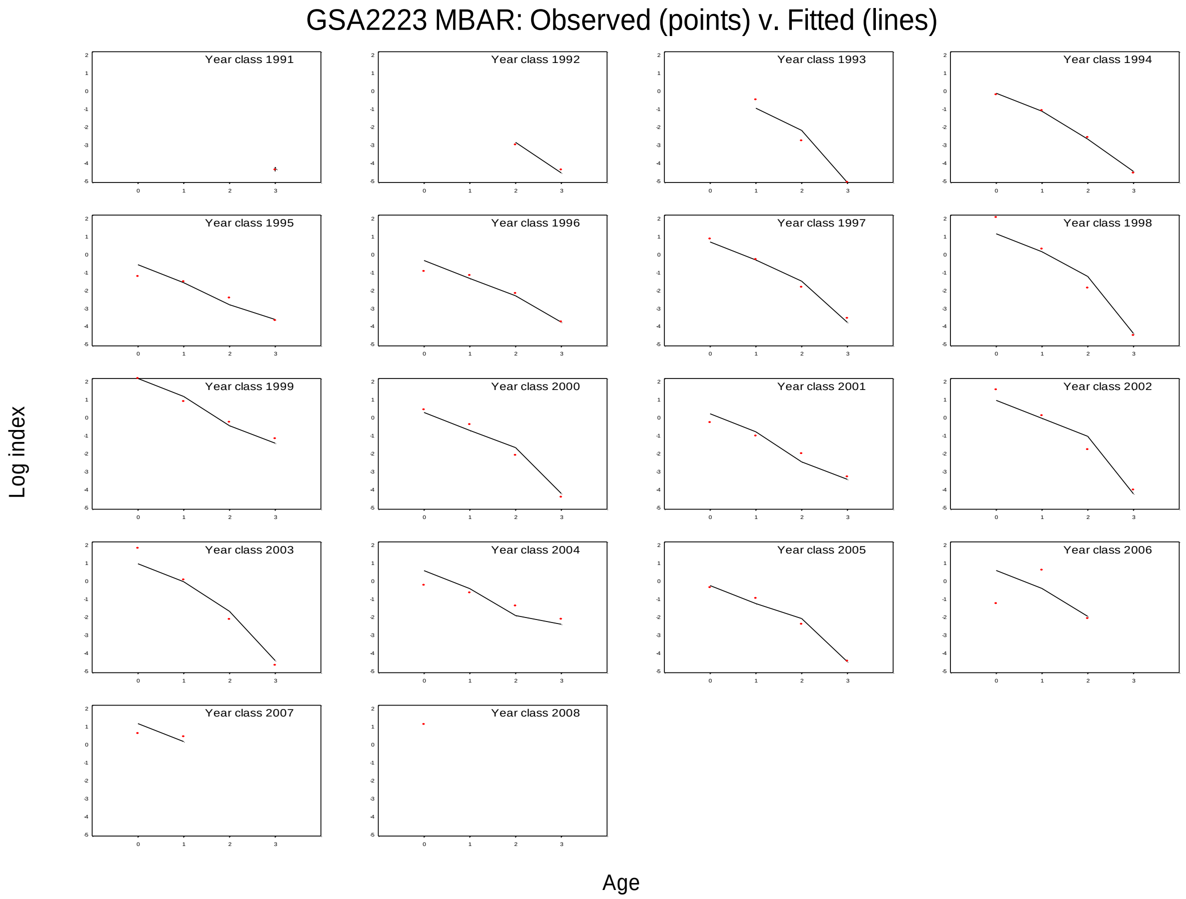



**Fig. 1.10.5.16. SURBA model diagnostic for red mullet in GSAs 22&23. A) Temporal trend in residuals by age B) Observed (points) and fitted (lines) year classes.**

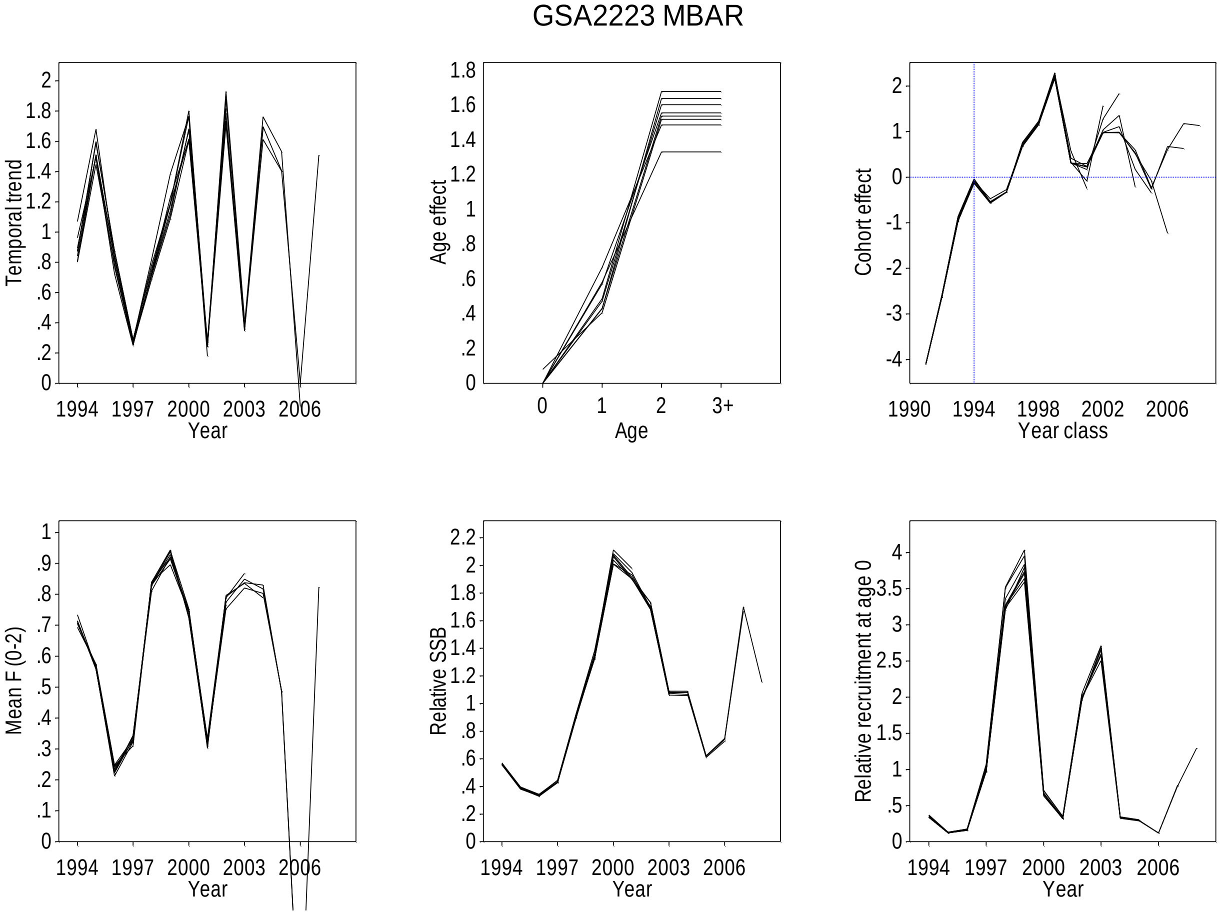



**Fig. 1.10.5.17. SURBA model of red mullet in GSAs 22&23: retrospective analysis.**

### 1.10.6 *Short term prediction for 2008 and 2009*

#### 1.10.6.1 Justification

No forecast analyses were conducted.

#### 1.10.6.2 Input parameters

No forecast analyses were conducted.

#### 1.10.6.3 Results

### 1.10.7 *Medium term prediction* -

#### 1.10.7.1 Justification

No forecast analyses were conducted.

#### 1.10.7.2 Input parameters

No forecast analyses were conducted.

#### 1.10.7.3 Results

### 1.10.8 *Long term prediction*

#### 1.10.8.1 Justification

No forecast analyses were conducted.

#### 1.10.8.2 Input parameters

No forecast analyses were conducted.

#### 1.10.8.3 Results

### 1.10.9 *Scientific advice*

#### 1.10.9.1 Short term considerations

***State of the spawning stock size***

In the absence of proposed or agreed precautionary reference is not possible to fully evaluate the status of the spawning stock size.

SURBA results, due to the poor data fit, are not considered reliable to evalute the status of the spawning biomass.
The total biomass at sea in 2008 estimated with the production model using the logistic approach, is below $B_{MSY}$ (i.e. about 90% of $B_{MSY}$ ($B/B_{MSY}$ = 0.91)).

***State of recruitment***

SURBA results, due to the poor data fit, are not considered reliable to evalute the status of the recruitment.

***State of exploitation***

VIT results suggest that the red mullet in GSA22&23 was exploited unsustainably in 2005 and 2008 as current F (0.56) was larger than the proxy of $F_{MSY}$ ($F_{(0.1)}$=0.52).

According to ASPIC results, red mullet in GSA22&23 can be considered exploited unsustainably in 2007 (current $F/F_{MSY}$=1.18). A value of $F_{MSY}$ of 0.308 was estimated while the model estimated for the most recent year (2007) a value of F of about 0.32

SURBA results, due to the poor data fit, are not considered reliable to evalute the exploitation status of red mullet in GSA 22&23.

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Efron, B. E., and G. Gong. 1983. A leisurely look at the bootstrap, the jackknife, and cross-validation. American Statistician 47: 36–48.

Moutopoulos D.K., Stergiou K.I. 2012. Spatial disentangling of Greek commercial fisheries landings by gear between 1928-2007. Journal of Biological Research, 18: 265-279.

Prager, M.H. 2005. User's Manual for ASPIC: Stock Production Model Incorporating Covariates (ver. 5) and Auxiliary Programs. National Marine Fisheries Service. Population Dynamic Team.

Reñones O., Massuti E., Morales- Nin B. (1985) Life history of the red mullet Mullus surmuletus from the bottom-trawl fishery off the Island of Majorca (north-west Mediterranean) Marine Biology (1995) 123:411-419

## 1.11 **Stock assessment of red mullet *Mullus surmuletus* GSA 20**

### 1.11.1 *Stock identification and biological features*

#### 1.11.1.1 Stock Identification

The stripped red mullet is distributed along the shelf and part of the slope of all the Mediterranean countries.. All the year classes and nursery and spawning areas are well distributed along the narrow Mediterranean shelves. There is not a definition of unit stocks in the area. Due to the lack of information about the structure of stripped red mullet (*Mullus surmuletus*) in the eastern Mediterranean, this stock was assumed to be confined within the GSA 20 boundaries.

The striped red mullet is a demersal fish mostly found in depths down to 200 m, generally found on bottoms with heterogeneous granulometry and often in *Posidonia* beds but can be found at depths over 400m. Apart from the Mediterranean, it inhabits the Eastern Atlantic from the North Sea to Senegal (Fischer et al., 1987). It is a species with a high commercial value and target species of many demersal fisheries operating in the Mediterranean Sea. Certain geological characteristics, such as the structure of the shelf, affect its distributions, as it prefers rough substrates (Hureau, 1986; Fisher *et al.*, 1987) and narrow shelf areas with rocky or sandy bottoms (Lombarte *et al*., 2000). Survey indices showed higher abundances in the eastern Mediterranean basins for the years 1994-1999, with a larger presence of recruits in the southern Aegean Sea (Tserpes *et al*., 2002).

#### 1.11.1.2 Growth and Natural Mortality

*Mullus surmuletus* is a fast growing species, The parameters used are reported below and are considered suitable for the description of an average growth performance valid for all the analysed GSAs.

The growth parameters for the whole population used here are: asymptotic length Loo = 31.28 cm; growth coefficient, K = 0.211 $yr^{-1}$; theoretical age when length is zero, to = - 2.348 yr.

Growth parameters
Linf= 40.05
K= 0.164
to= -1.883

Much more fast growth of the species is assumed in a study in GSA9 (Voliani et al, 1998)
Linf= 26.4
K= 0.69
to= -0.47

L/W
a=0.0084
b=3.118

A vector M decreasing with age derived from PRODBIOM (Abella, Caddy & Serena, 1997) was used was estimated:

M = 1 (age 0), 0.6 (age1), 0.4 (age 2), 0.3 (ages 3-5+)

#### 1.11.1.3 Maturity

The species reaches massively the sexual maturity at one year old. Observations of proportion of mature individuals by size and analysis with the standard procedure have produced the following sizes at age maturity by sex.

**Proportion of mature**

| Age | | | |
|---|---|---|---|
| 0 | 1 | 2 | 3 and >3 |
| 0 | 0.95 | 1 | 1 |

### 1.11.2 *Fisheries*

#### 1.11.2.1 General description of fisheries

*Mullus surmuletus* is one of the most important target species caught by trawlers and trammel netters in Greece (Tzanatos et al., 2005; Gozalvo et al., 2011) and is an important component of a species assemblage that is mainly targeted by the small scale  fisheries operating near shore.

On average in the analysed period, the main catches of *Mullus surmuletus* proceed in GSA20  from small scale fisheries (72%), while trawlers catches represent about 22% followed by beach seines (5%) and only 1% from purse seiners.

The exerted fishing pressure on this species is conditioned by the structural composition of the fractions of the fleets that operate in the respective areas, by the characteristics of the potentially exploitable grounds and also by differences in the fisheries' target choices among fleets and zones. *Mullus surmuletus* catch rates are higher during the post-recruitment period (from September to November).  The trawlers and the small scale artisanal vessels with set nets are the main categories that exploit the species in the estudied areas.

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***Management regulations applicable in 2009 and changes in 2010***

From Gozalvo et al. (2011):

- Bottom trawl:
    - Minimum distance from the coast
    - Mesh size dimensions
    - Temporal closure
    - Minimum fishing depth
- Netters:
    - Maximum dimension of nets
    - Minimum mesh size
    - Type of thread

RD 917/1966 is the principal law regulating the operation of trawlers. Although this law is still in effect, it has been superseded by EC Regulation 1626/1994, and its replacement Regulation 1967/2006. The main restrictions established by Greek and European legislation are:

(1) establishment of a total exclusion zone one and a half mile from the coastline of the mainland and the islands,
(2) a total fishing ban from the 1st of June till the end of September,
(3) establishment of a total exclusion zone which is: either a zone three miles from the coastal line or a zone shallower than 50 m,
(4) minimum cod-end mesh size is 40 mm (EC regulation 1967/2006); from 1 July 2008, the net shall be replaced by a square-meshed net of 40 mm at the cod-end or, at the duly justified request of the ship owner, by a diamond meshed net of 50 mm.

Additional restrictions exist for bottom trawling in specific areas: in Amvrakikos Gulf and some parts of the Korinthiakos Gulf and the Ionian Sea, trawling is prohibited all year around, while in Patraikos Gulf trawling is prohibited from the 1st of March till the end of November and in the entire Korinthiakos is prohibited from from the 1st of April till the end of November (Presidential Decree 698/81).

The operation of the bottom set nets is subject to the following main restrictions:
(1) the maximum total length of the trammel net is 6000 m.
(2) the minimum mesh size opening is 16 mm.
(3) monofilament or twine diameter of the net should not exceed 0.5 mm.
(4) the maximum drop of a combined trammel and gill net should not exceed 10 m and the length of combined nets should not exceed 2,500 m.

For the bottom longlines the only restriction derives from ER 1967/2006 and referred to maximum number of hooks per fishers (1000 hooks) and the total maximum number of hooks per vessel (5000 hooks)

#### 1.11.2.2 Catches

***Landings***

Landings data used in the production model are estimates of landings of stripped red mullet and effort for GSA 22 and 23 provided by Moutoupolous and Stergiou (2012) FAO-FISHSTAT GFCM database. The annual landings, mostly proceeding from small scale fisheries, ranged in the last 4 years from 548 to 632 tons in GSA20. Landings from trawlers and small scale fishing vessels dominate by far. Landings size show a very high seasonal variability, with peaks at the end of summer (september) determined by the increase in availability/vulnerability after the massive recruitment on the coastal area.

Figure 1.11.2.1 shows the historical landings of striped red mullet in GSA 20 from the mentioned source, for the different gears.

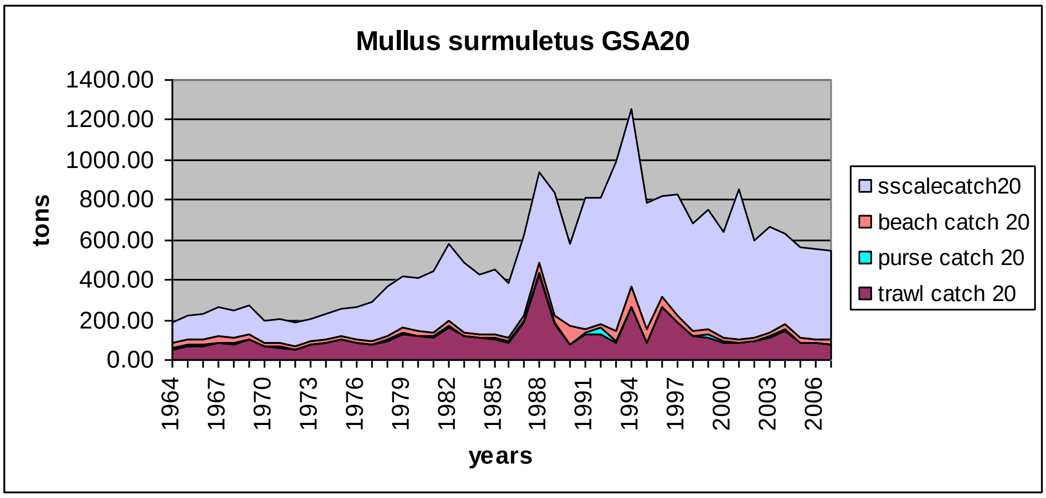


**Fig 1.11.2.1. Landings of *M.surmuletus* for GSA20 for the years 1964-2007.**

There is no information on size/age structure of the landings for this species

***Discards***

Discards of undersized individuals is not well defined.

***Fishing effort***

The fishing effort for each year was reconstructed using several sources.

Effort is expressed here as activity (number of days at sea) x overall HP corrected by a factor that takes into account the increased fishing power due to technological and experience improvements (technological kreeping). A yearly increase in fishing efficiency was estimated to be of 2.72% (see Section 1 for details).

### 1.11.3 *Scientific surveys*

#### 1.11.3.1 MEDITS

***Methods***

Based on the DCR data call, abundance and biomass indices were recalculated and presented in section 1 of this report.

Since 1994, MEDITS trawl surveys has been regularly carried out each year during spring. Based on the DCR data call, abundance and biomass indices were calculated. In GSA 20 the following number of hauls was reported per depth stratum (Table 1.11.3.1).

**Tab. 1.11.3.1. Number of hauls per year and depth stratum in GSA 20.**

| Stratum | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2003 | 2004 | 2005 | 2006 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **010-050** | 10 | 10 | 11 | 10 | 13 | 12 | 12 | 13 | 13 | 13 | 14 | 12 | 13 |
| **050-100** | 17 | 21 | 22 | 28 | 23 | 26 | 22 | 25 | 25 | 23 | 24 | 26 | 26 |
| **100-200** | 19 | 25 | 37 | 36 | 37 | 33 | 37 | 35 | 36 | 43 | 41 | 41 | 40 |
| **200-500** | 28 | 35 | 44 | 50 | 51 | 51 | 50 | 48 | 51 | 52 | 52 | 52 | 52 |
| **500-800** | 18 | 12 | 19 | 21 | 22 | 21 | 20 | 17 | 17 | 16 | 17 | 16 | 17 |
| **TOTAL** | 92 | 103 | 133 | 145 | 146 | 143 | 141 | 138 | 142 | 147 | 148 | 147 | 148 |

Data were standardized to 60 minutes haul duration, and stratified means were calculated. Length distributions represented an aggregation (sum) of all standardized length frequencies

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-Poisson. Indeed, data may be better modeled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (sub-samples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

### *Geographical distribution patterns*

Figure 1.11.3.2. provides the distribution of sampling hauls of the MEDITS survey in GSA 20.

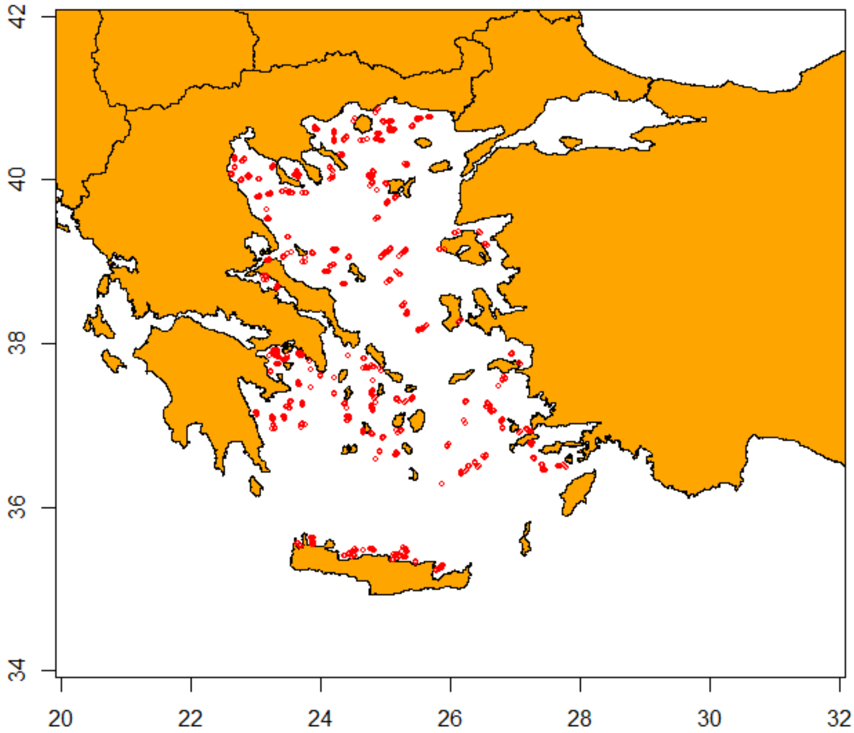


**Fig 1.11.3.2. Distribution of sampling hauls of the MEDITS survey in GSA 22&23.**

***Trends in abundance and biomass***

Fishery independent information regarding the state of the red mullet in GSA 20 was derived from the international survey MEDITS. Figure 1.11.3.2 displays the estimated trends in abundance and biomass.

**Table 1.11.3.2. Index of abundance (n/km$^2$) and biomass (kg/km$^2$) for *M. surmulletus* in GSA 20.**

| GSA20 | |
|---|---|
| N/60' | Kg/60' |
| 1.8 | 0.1 |
| 0.1 | 0.0 |
| 0.1 | 0.0 |
| 0.1 | 0.0 |
| 0.1 | 0.0 |
| 0.3 | 0.0 |
| 0.7 | 0.1 |
| 0.7 | 0.0 |
| | |
| 0.4 | 0.1 |
| 1.2 | 0.1 |
| 0.1 | 0.0 |
| 0.1 | 0.0 |
| | |
| 0.77 | 0.04 |

The estimated abundance and biomass indices in GSA20 reveal high fluctuations since 1994 with a very low mean abundance index of about 0.3-0.4 n/hr, without any trend.

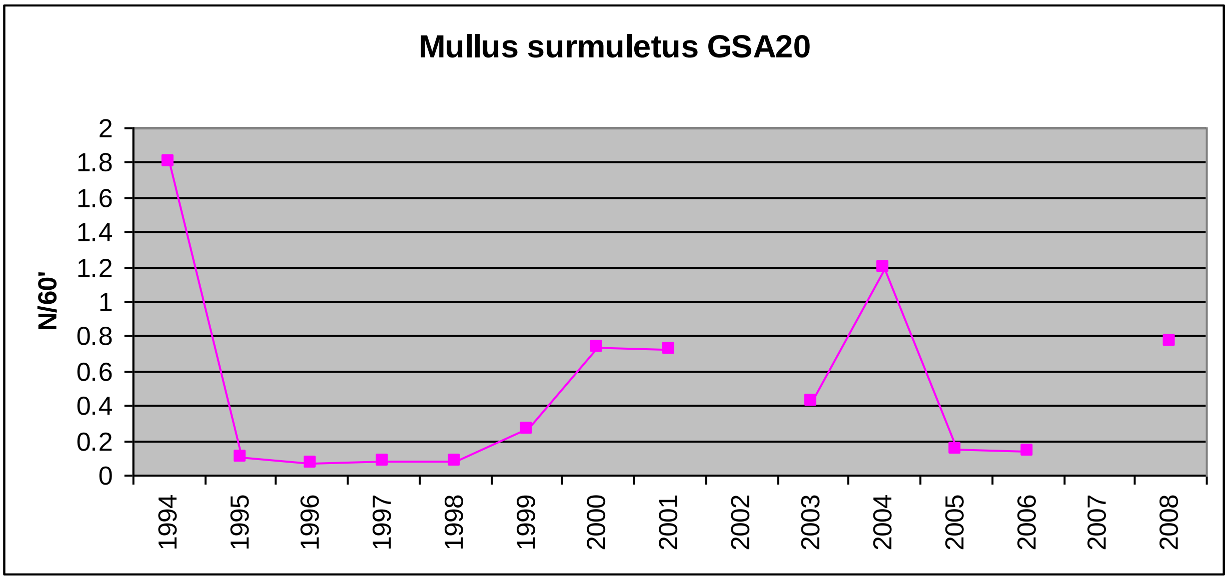


**Fig 1.11.3.2. Index of abundance (n/h) for *M.surmulletus* in GSA20.**

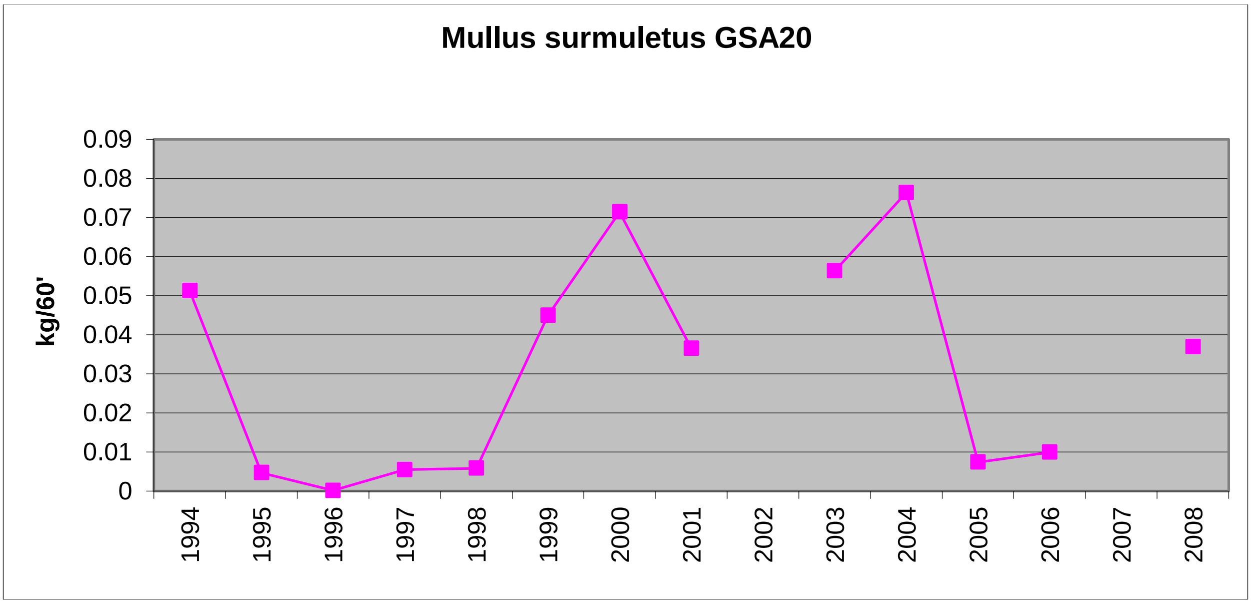


**Fig. 1.11.3.3. Index of biomass (kg/h) for *M. surmulletus* in GSA 20.**

***Trends in abundance by length or age***

Although the relatively long time series of data available from the MEDITS surveys should provide useful data set to analyse the trend of *Mullus surmuletus* stock in GSA 20, the number of individuals measured by year is too low (Figure 1.11.3.4, Table 1.11.3.3) to perform a reliable assessment of the status of this species based on survey data. For this reason, no analysis based on survey data was performed.

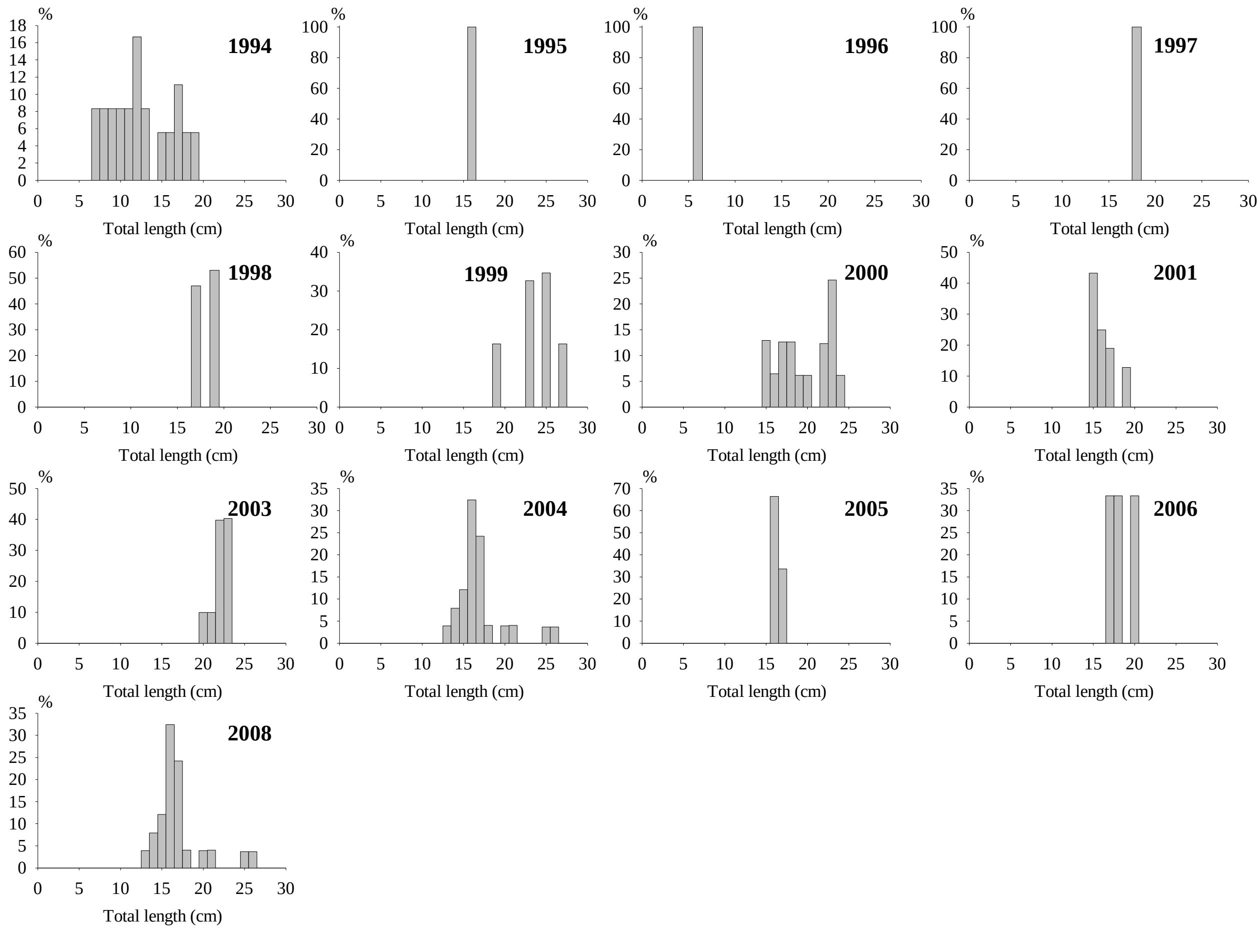


**Fig. 1.11.3.4. MEDITS length frequency distributions of striped red mullet in the GSA 20.**

**Table 1.11.3.3. Number of individuals measured by year for striped red mullet in the GSA 20.**

| 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| 36 | 2 | 2 | 2 | 3 | 7 | 21 | 32 | 11 | 48 | 6 |

## 1.11.4 *Assessment of historic stock parameters*

Results

### 1.11.4.1 Method 1: Stock-Production model

***Justification***

The analysis was performed using the ASPIC.5 software (A Stock-Production model Incorporating Covariates) (Prager, 1994, 2005) assuming a Schaefer (1954) model. This program implements a non-equilibrium, continuous-time, observation-error estimator for the dynamic production model (Schnute, 1977; Prager, 1994). The model was used to estimate *r* (the intrinsic rate of population growth), *MSY*, the ratios of both current biomass or *F* to the biomass or F at which *MSY* can be attained, and *q* (the catchability coefficient, the proportion of total stock removed by one unit of fishing effort).

***Input parameters***

Input data consist in 4 sets of time series from 1964 to 2007 of total landings (in tons) and fishing effort expressed as days fishing x HP. Data regards landings and effort related to trawling, purse seining, beach seines and other small scale fisheries mostly including set nets. No information was available in order to determine more detailed specific effort targeting the stock in question between each fishing strategy and hence for the analysis it was assumed that neither targets for each fishing technique nor areas did change along the studied period.

MEDITS trawls surveys estimates of the index of abundance between 1994 and 2008 were available but the series was incomplete, shows high fluctuating values and the number of individuals measured by year is too low for being included in this analysis. For this reason, no analysis based on survey data were performed even though an attempt of including such information in the analysis was done. Such attempt resulted unsuccessful because lacking of enough correlation with the cpue's time series.
Considering the lower importance of beach seines and purse seines in the overall catch and also that the stocks in question were not the target of such fisheries, a lower weight were assigned to the information proceeding from such fisheries for the computations. As a setting option of ASPIC, priority (more weight) was assigned to the information on landings than to effort, considered the last measured with lower precision.
Several models were tested (Schaefer, Fox, Generalized), but the only that supplied fairly good fittings and reasonable results was the logistic Schaefer model. From the bootstrap results, bias-corrected (BC) confidence intervals were computed by standard methods (Efron and Gong 1983). 1000 bootstrap trials were performed computing 90% confidence intervals.

**Table 1.11.4.1. ASPIC input parameters of the FIT mode for GSA 20.**

| **B1/K** | **MSY** | **Range of MSY** | **K** | **Range of K** | **Fishing fleet** | **q (mean (CPUE) / 2*max(Y))** |
|---|---|---|---|---|---|---|
| 0.5 | 7.00E+2 | 4.00E+02 to 2.00E+03 | 8.000E+03 | 4.00E+03 to 2.500E+04 | Trawlers<br>Purse seine<br>Beach seine<br>Small scale | 4.429E-08<br>1.776E-08<br>2.177E-08<br>1.522E-08 |

***Results***

As follows the main results of the analysis for the GSA20 are shown:

## *Mullus surmulletus* GSA20

| **Model** | **MSY (tons)** | **$B_{MSY}$ (tons)** | **$F_{MSY}$** | **$f_{MSY}$ Beach seine** | **$f_{MSY}$ Trawl** | **$f_{MSY}$ Purse seine** | **$f_{MSY}$ Small scale** |
|---|---|---|---|---|---|---|---|
| **Logistic** | 717 | 2692 | 0.269 | 3.400E+07 | 3.556E+07 | 1.502E+08 | 2.911E+07 |

| **Model** | **MSY** | | | **$F_{MSY}$** | | |
|---|---|---|---|---|---|---|
| | **80% lower** | | **80% higher** | **80% lower** | | **80% higher** |
| **Logistic** | 422 | 716 | 1021 | 0.235 | 0.269 | 0.291 |

MANAGEMENT and DERIVED PARAMETER ESTIMATES -----------------------------------------------------------------------------------------------------------------

| Parameter | | Estimate |
|---|---|---|
| B./Bmsy | Ratio: B(2008)/Bmsy | 0.9489 |
| F./Fmsy | Ratio: F(2007)/Fmsy | 0. 8319 |
| r | | 0.532 |

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

| Obs | Year or ID | Estimated total F mort | Estimated starting biomass | Estimated average biomass | Observed total yield | Model total yield | Estimated surplus production | Ratio of F mort to Fmsy | Ratio of biomass to Bmsy |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1964 | 0.022 | 1.002E+04 | 8.394E+03 | 1.852E+02 | 1.852E+02 | -2.556E+03 | 8.288E-02 | 3.723E+00 |
| 2 | 1965 | 0.033 | 7.282E+03 | 6.669E+03 | 2.232E+02 | 2.232E+02 | -8.562E+02 | 1.258E-01 | 2.705E+00 |
| 3 | 1966 | 0.038 | 6.203E+03 | 5.906E+03 | 2.271E+02 | 2.271E+02 | -3.066E+02 | 1.444E-01 | 2.304E+00 |
| 4 | 1967 | 0.048 | 5.669E+03 | 5.493E+03 | 2.611E+02 | 2.611E+02 | -5.943E+01 | 1.786E-01 | 2.106E+00 |
| 5 | 1968 | 0.047 | 5.348E+03 | 5.251E+03 | 2.479E+02 | 2.479E+02 | 6.925E+01 | 1.774E-01 | 1.986E+00 |
| 6 | 1969 | 0.053 | 5.170E+03 | 5.100E+03 | 2.708E+02 | 2.708E+02 | 1.433E+02 | 1.995E-01 | 1.920E+00 |
| 7 | 1970 | 0.039 | 5.042E+03 | 5.031E+03 | 1.975E+02 | 1.975E+02 | 1.761E+02 | 1.475E-01 | 1.873E+00 |
| 8 | 1971 | 0.042 | 5.021E+03 | 5.009E+03 | 2.085E+02 | 2.085E+02 | 1.862E+02 | 1.564E-01 | 1.865E+00 |
| 9 | 1972 | 0.037 | 4.999E+03 | 5.001E+03 | 1.850E+02 | 1.850E+02 | 1.897E+02 | 1.389E-01 | 1.857E+00 |
| 10 | 1973 | 0.040 | 5.003E+03 | 4.998E+03 | 2.012E+02 | 2.012E+02 | 1.912E+02 | 1.512E-01 | 1.858E+00 |
| 11 | 1974 | 0.046 | 4.993E+03 | 4.978E+03 | 2.279E+02 | 2.279E+02 | 2.001E+02 | 1.720E-01 | 1.855E+00 |
| 12 | 1975 | 0.052 | 4.966E+03 | 4.942E+03 | 2.594E+02 | 2.594E+02 | 2.163E+02 | 1.972E-01 | 1.844E+00 |
| 13 | 1976 | 0.054 | 4.922E+03 | 4.906E+03 | 2.635E+02 | 2.635E+02 | 2.324E+02 | 2.018E-01 | 1.828E+00 |
| 14 | 1977 | 0.059 | 4.891E+03 | 4.869E+03 | 2.892E+02 | 2.892E+02 | 2.482E+02 | 2.231E-01 | 1.817E+00 |
| 15 | 1978 | 0.076 | 4.850E+03 | 4.802E+03 | 3.661E+02 | 3.661E+02 | 2.766E+02 | 2.864E-01 | 1.801E+00 |
| 16 | 1979 | 0.089 | 4.761E+03 | 4.705E+03 | 4.190E+02 | 4.190E+02 | 3.160E+02 | 3.346E-01 | 1.768E+00 |
| 17 | 1980 | 0.090 | 4.658E+03 | 4.623E+03 | 4.139E+02 | 4.139E+02 | 3.483E+02 | 3.364E-01 | 1.730E+00 |
| 18 | 1981 | 0.098 | 4.592E+03 | 4.553E+03 | 4.468E+02 | 4.468E+02 | 3.743E+02 | 3.687E-01 | 1.706E+00 |
| 19 | 1982 | 0.132 | 4.520E+03 | 4.430E+03 | 5.843E+02 | 5.843E+02 | 4.179E+02 | 4.955E-01 | 1.679E+00 |
| 20 | 1983 | 0.113 | 4.353E+03 | 4.334E+03 | 4.875E+02 | 4.875E+02 | 4.504E+02 | 4.227E-01 | 1.617E+00 |
| 21 | 1984 | 0.099 | 4.316E+03 | 4.329E+03 | 4.282E+02 | 4.282E+02 | 4.519E+02 | 3.716E-01 | 1.603E+00 |
| 22 | 1985 | 0.104 | 4.340E+03 | 4.340E+03 | 4.492E+02 | 4.492E+02 | 4.484E+02 | 3.889E-01 | 1.612E+00 |
| 23 | 1986 | 0.089 | 4.339E+03 | 4.367E+03 | 3.879E+02 | 3.879E+02 | 4.395E+02 | 3.337E-01 | 1.612E+00 |
| 24 | 1987 | 0.144 | 4.391E+03 | 4.304E+03 | 6.201E+02 | 6.201E+02 | 4.596E+02 | 5.413E-01 | 1.631E+00 |
| 25 | 1988 | 0.234 | 4.230E+03 | 4.015E+03 | 9.405E+02 | 9.405E+02 | 5.425E+02 | 8.801E-01 | 1.571E+00 |
| 26 | 1989 | 0.225 | 3.832E+03 | 3.712E+03 | 8.369E+02 | 8.369E+02 | 6.134E+02 | 8.470E-01 | 1.423E+00 |
| 27 | 1990 | 0.159 | 3.609E+03 | 3.635E+03 | 5.783E+02 | 5.783E+02 | 6.287E+02 | 5.976E-01 | 1.340E+00 |
| 28 | 1991 | 0.228 | 3.659E+03 | 3.567E+03 | 8.140E+02 | 8.140E+02 | 6.408E+02 | 8.575E-01 | 1.359E+00 |
| 29 | 1992 | 0.237 | 3.486E+03 | 3.410E+03 | 8.089E+02 | 8.089E+02 | 6.656E+02 | 8.913E-01 | 1.295E+00 |
| 30 | 1993 | 0.310 | 3.343E+03 | 3.185E+03 | 9.868E+02 | 9.868E+02 | 6.919E+02 | 1.164E+00 | 1.241E+00 |
| 31 | 1994 | 0.456 | 3.048E+03 | 2.755E+03 | 1.257E+03 | 1.257E+03 | 7.139E+02 | 1.714E+00 | 1.132E+00 |
| 32 | 1995 | 0.319 | 2.505E+03 | 2.466E+03 | 7.859E+02 | 7.859E+02 | 7.115E+02 | 1.197E+00 | 9.303E-01 |
| 33 | 1996 | 0.347 | 2.430E+03 | 2.369E+03 | 8.229E+02 | 8.229E+02 | 7.062E+02 | 1.305E+00 | 9.026E-01 |
| 34 | 1997 | 0.371 | 2.314E+03 | 2.243E+03 | 8.315E+02 | 8.315E+02 | 6.965E+02 | 1.393E+00 | 8.593E-01 |
| 35 | 1998 | 0.315 | 2.179E+03 | 2.181E+03 | 6.871E+02 | 6.871E+02 | 6.907E+02 | 1.184E+00 | 8.092E-01 |
| 36 | 1999 | 0.350 | 2.182E+03 | 2.148E+03 | 7.529E+02 | 7.529E+02 | 6.873E+02 | 1.317E+00 | 8.105E-01 |
| 37 | 2000 | 0.299 | 2.117E+03 | 2.141E+03 | 6.400E+02 | 6.400E+02 | 6.865E+02 | 1.123E+00 | 7.862E-01 |
| 38 | 2001 | 0.412 | 2.163E+03 | 2.071E+03 | 8.539E+02 | 8.539E+02 | 6.782E+02 | 1.549E+00 | 8.034E-01 |
| 39 | 2002 | 0.297 | 1.988E+03 | 2.024E+03 | 6.008E+02 | 6.008E+02 | 6.725E+02 | 1.115E+00 | 7.382E-01 |
| 40 | 2003 | 0.324 | 2.059E+03 | 2.064E+03 | 6.679E+02 | 6.679E+02 | 6.776E+02 | 1.216E+00 | 7.648E-01 |
| 41 | 2004 | 0.302 | 2.069E+03 | 2.094E+03 | 6.325E+02 | 6.325E+02 | 6.812E+02 | 1.135E+00 | 7.684E-01 |
| 42 | 2005 | 0.260 | 2.118E+03 | 2.181E+03 | 5.668E+02 | 5.668E+02 | 6.907E+02 | 9.763E-01 | 7.865E-01 |
| 43 | 2006 | 0.238 | 2.242E+03 | 2.318E+03 | 5.528E+02 | 5.528E+02 | 7.026E+02 | 8.958E-01 | 8.325E-01 |
| 44 | 2007 | 0.221 | 2.391E+03 | 2.476E+03 | 5.482E+02 | 5.482E+02 | 7.118E+02 | 8.319E-01 | 8.882E-01 |
| 45 | 2008 | | 2.555E+03 | | | | 9.489E-01 | | |

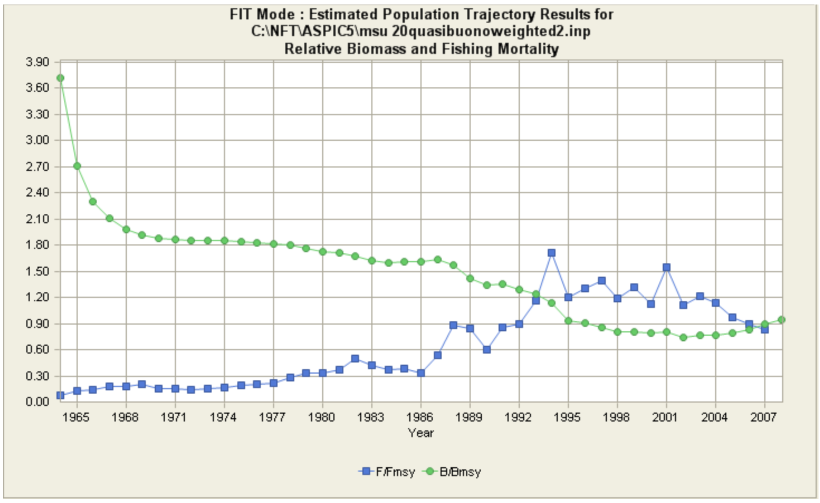


**Fig.1.11.4.2. $F/F_{MSY}$ and $B/B_{MSY}$ estimated for each year.**

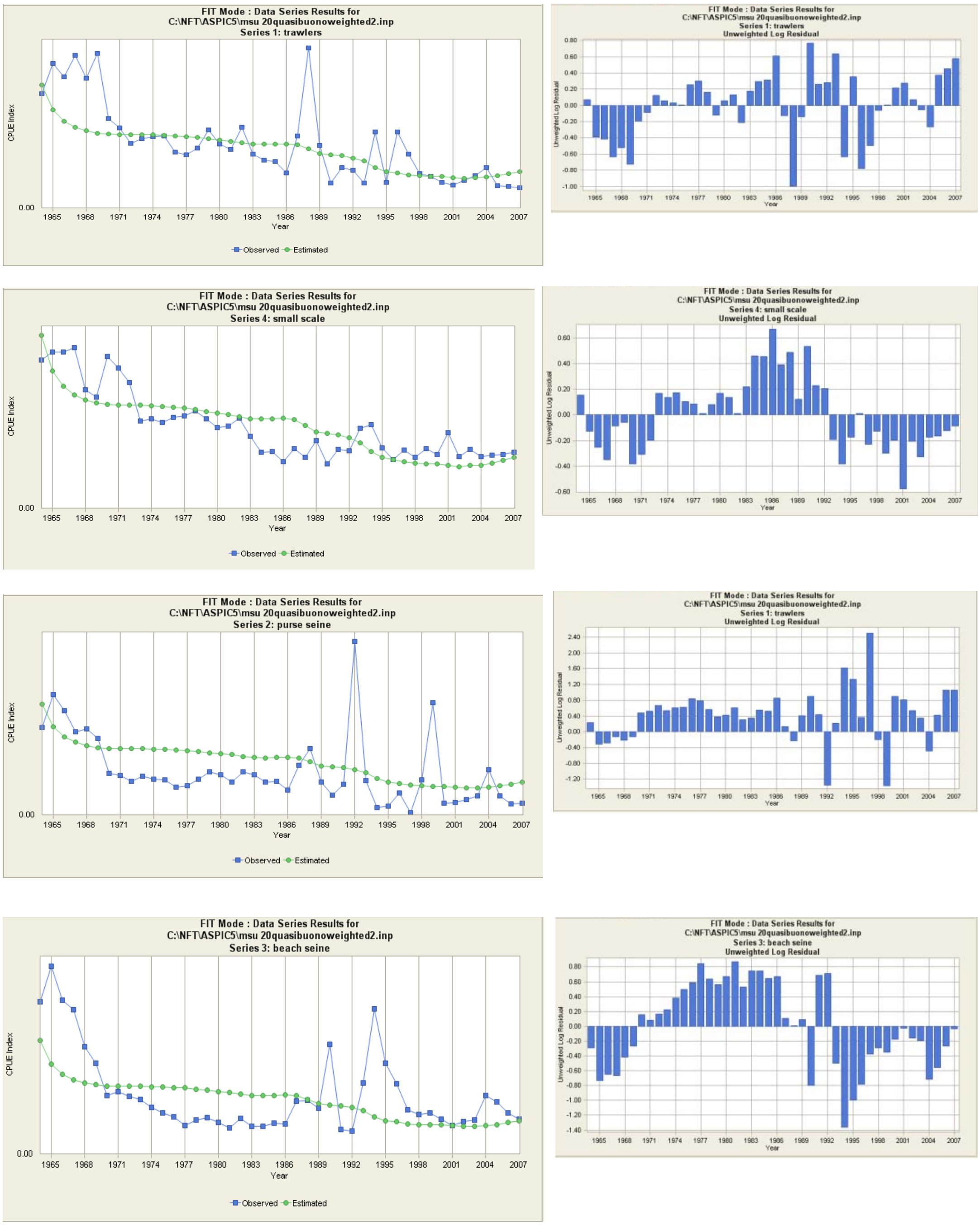


**Fig 1.11.4.3. Model fitting for each gear/strategy and model residuals.**

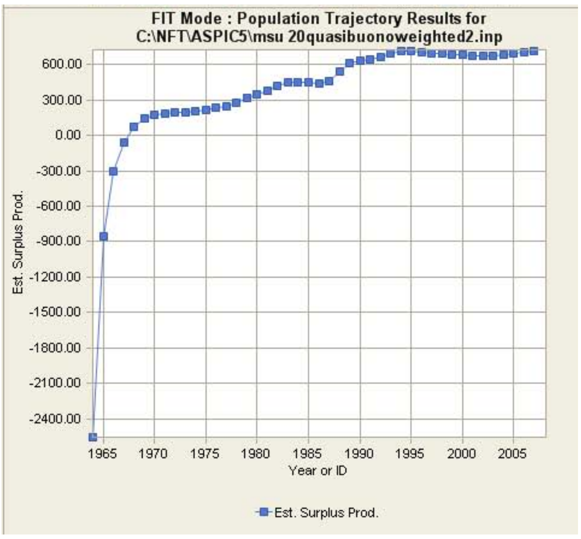


**Figure 1.11.4.4. Estimated surplus production of *Mullus surmulletus* in GSA 20 using the Logistic Schaefer model for the period 1964-2008.**

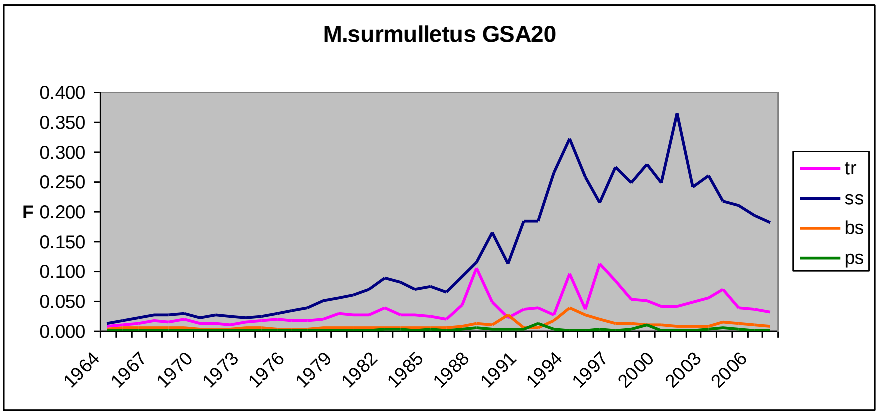


**Fig.1.11.4.5. F vector by gear for *Mullus surmuletus* in GSA20 (tr:trawlers; ss:small-scale; bs:beach seines; ps:purse seiners).**

### *State of the spawning stock size*

There are not agreed precautionary reference levels and hence is not possible to fully evaluate the status of the spawning stock size.

SURBA results, due to the poor data fit, are not considered reliable to evalute the status of the spawning biomass.
The total biomass at sea in 2008 estimated with the production model using the logistic approach, is below $B_{MSY}$ (i.e. about 90% of $B_{MSY}$ ($B/B_{MSY}$ = 0.88)).

### *State of recruitment*

SURBA results, due to the poor data fit, are not considered reliable to evalute the status of the recruitment.

***State of exploitation***

The estimated reference point ($F_{MSY}$ = 0.28) is above the values of current F estimated by Aspic (0.22). Thus, according to ASPIC results, in 2007 the stock can be considered sustainably exploited (current $F/F_{MSY}$=0.83).

### 1.11.4.2 Data quality and availability

Data used in ASPIC proceed from a reconstruction of landings derived from different sources. A number of gaps and inconsistencies can be found. The main problems regards the quality of effort information, in particular the availability of information on total effort only by type of gear or group of gears without any distinction by métier. For species that shows a limited bathymetric distribution related to the fleet operational area as *Mullus surmulletus*, the lack of such information does not allow to quantify which is the real amount of effort directed to the species in question, having the bathymetric distribution of fishing fleets (i.e. trawlers) more wider depth range. Moreover, no data on discards is available.

This lack of more precise information obliged to use the overall effort by gear assuming that the pattern of spatial distribution and target of the fleets remained almost unchanged along the analysed period and also the discards rate. Only in this way it is possible to assume that the observed changes in abundance (cpue) are mainly due to changes in fishing pressure on the stock in question.

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Voliani A., Abella A., Auteri R., Silvestri R. (1998). Nota sui parametri biologici di *Mullus surmuletus* L., 1758 nell'Arcipelago Toscano. Biol. Mar. Medit., 5(1):864-868

## 1.12 **Stock assessment of striped red mullet in GSA 22&23**

### 1.12.1 *Stock identification and biological features*

Stock Identification

The stripped red mullet is distributed along the shelf and part of the slope of all the Mediterranean countries. All the year classes and nursery and spawning areas are well distributed along the narrow Mediterranean shelves. There is not a definition of unit stocks in the area. Due to the lack of information about the structure of stripped red mullet (*Mullus surmuletus*) in the eastern Mediterranean, this stock was assumed to be confined within the GSAs boundaries. The striped red mullet is a demersal fish mostly found in depths down to 200 m, generally found on bottoms with heterogeneous granulometry and often in *Posidonia* beds but can be found at depths over 400m. Apart from the Mediterranean, it inhabits the Eastern Atlantic from the North Sea to Senegal (Fischer et al., 1987). It is a species with a high commercial value and target species of many demersal fisheries operating in the Mediterranean Sea. Certain geological characteristics, such as the structure of the shelf, affect its distributions, as it prefers rough substrates (Hureau, 1986; Fisher *et al.*, 1987) and narrow shelf areas with rocky or sandy bottoms (Lombarte *et al*., 2000). Survey indices showed higher abundances in the eastern Mediterranean basins for the years 1994-1999, with a larger presence of recruits in the southern Aegean Sea (Tserpes *et al*., 2002).

#### 1.12.1.1 Growth

*Mullus surmuletus* is a fast growing species. The parameters used are reported below and are considered suitable for the description of an average growth performance valid for all the analysed GSAs.

Growth model $L\infty$ = 40.05 cm; K = 0.164; t0 = -1.883

(Data source; Otolith readings individuals from the Balearic Islands in the framework of the Spanish National Data Collection Program).

Length weight relationship: a = 0.0084; b = 3.118

Vector of M and age, calculated from Caddy (1991) equation using the PRODBIOM Excel spreed sheet (Abella et al., 1997):

| Age | M |
|---|---|
| 0 | 1 |
| 1 | 0.6 |
| 2 | 0.4 |
| 3 | 0.3 |
| 4 | 0.3 |
| 5 | 0.3 |

#### 1.12.1.2 Maturity

### 1.12.2 *Fisheries*

#### 1.12.2.1 General description of fisheries

*Mullus surmuletus* is one of the most important target species caught by trawlers and trammel netters in Greece (Tzanatos et al., 2005; Gozalvo et al., 2011) and is an important component of a species assemblage that is mainly targeted by the small scale  fisheries operating near shore.

On average in the analysed period, the main catches of *Mullus surmuletus* proceed in GSA22&23 from small scale fisheries (66%), while trawlers catches represent about 27% followed by beach seines (4%) and only 1% from purse seiners. The exerted fishing pressure on this species is quite different because among areas because conditioned by the structural composition of the fractions of the fleets that operate in the respective areas, by the characteristics of the potentially exploitable grounds and also by differences in the fisheries' target choices among fleets and zones. *Mullus surmulletus* catch rates are higher during the post-recruitment period (from September to November). The trawlers and the small scale artisanal vessels with set nets are the main categories that exploit the species in the estudied areas.

***Management regulations***

From Gozalvo et al. (2011):

- Bottom trawl:
    - Minimum distance from the coast
    - Mesh size dimensions
    - Temporal closure
    - Minimum fishing depth
- Netters:
    - Maximum dimension of nets
    - Minimum mesh size
    - Type of thread

Catches

***Landings***

No information was available for striped red mullet in GSA 22&23 from DCR data (commercial data), so no Length Cohort Analysis could be performed. Fig 1.12.2.1 shows the historical landings of striped red mullet in GSA 22&23 from the EVOMED project, for the different gears (see Section 1 of this report for details).

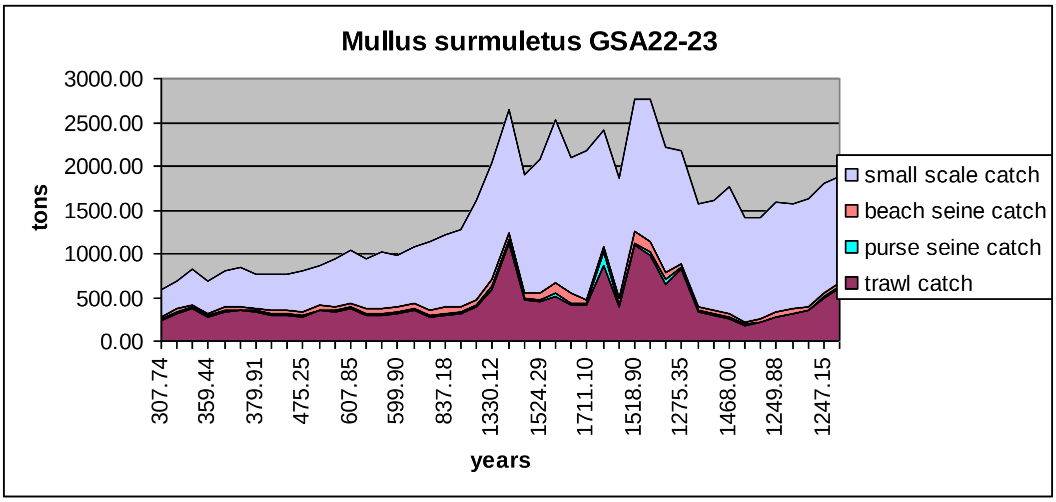



**Fig. 1.12.2.1. Historical andings of striped red mullet for different gears in GSA 22&23.**

***Discards***

Discards information are not available.

***Fishing effort***

The fishing effort for each year was reconstructed using several sources. Effort is expressed here as activity (number of days at sea) x overall HP corrected by a factor that takes into account the increased fishing power due to technological and experience improvements (i.e. technological kreeping). A yearly increase in fishing efficiency was estimated to be of 2.72% (see Section 1 of this report for details).

1.12.3 *Scientific surveys*

MEDITS surveys

***Methods***

Since 1994, MEDITS trawl surveys has been regularly carried out each year during spring. Based on the DCR data call, abundance and biomass indices were calculated. In GSA 22&23 the following number of hauls was reported per depth stratum (Table 1.12.2.1).

**Table 1.12.2.1. Number of hauls per year and depth stratum in GSA22&23, 1994-2008.**

| DEPTH_STRATUM | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2003 | 2004 | 2005 | 2006 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 010-050 | 10 | 10 | 11 | 10 | 13 | 12 | 13 | 13 | 13 | 13 | 14 | 14 | 13 |
| 050-100 | 19 | 21 | 22 | 28 | 24 | 26 | 21 | 25 | 25 | 23 | 24 | 24 | 27 |
| 100-200 | 19 | 26 | 38 | 36 | 36 | 33 | 38 | 35 | 36 | 43 | 41 | 41 | 40 |
| 200-500 | 32 | 35 | 45 | 50 | 51 | 54 | 50 | 48 | 51 | 53 | 52 | 52 | 52 |
| 500-800 | 18 | 13 | 19 | 22 | 22 | 21 | 20 | 17 | 17 | 17 | 17 | 17 | 17 |

Data were standardized to 60 minutes haul duration, and stratified means were calculated. Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance and finally aggregated (sum) over the strata to the GSA.

***Geographical distribution patterns***

***Trends in abundance and biomass***

Fig. 1.12.3.1 displays the biomass trends in GSA 22&23. Biomass showed oscillations along the data series, with the highest values in 1998 and 2003.

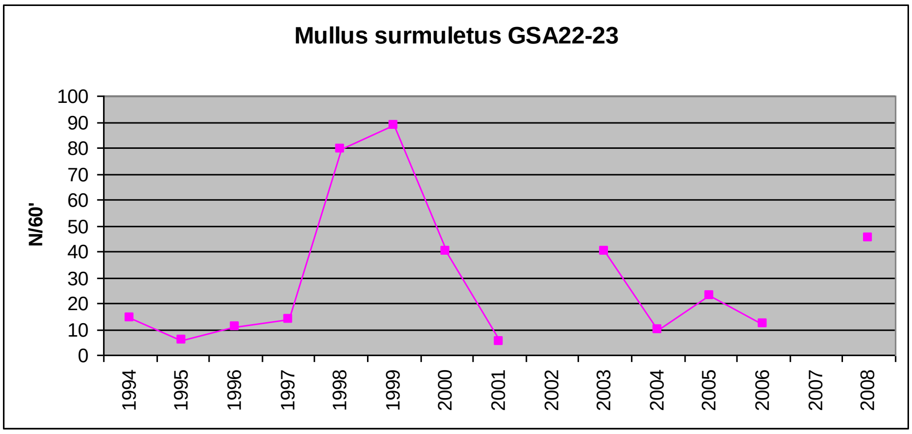



**Fig. 1.12.3.1. Index of abundance (n/km$^2$) for *M.surmulletus* in GSA 22&23.**

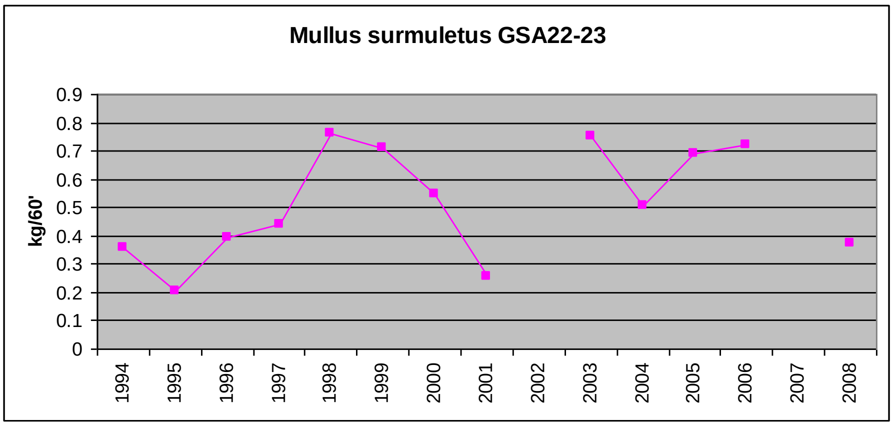



**Fig. 1.12.3.2. Index of biomass (kg/h) for *M.surmulletus* in GSA 22&23.**

***Trends in abundance by length or age***

No analyses were conducted.

***Trends in growth***

No analyses were conducted.

***Trends in maturity***

No analysis were conducted.

### 1.12.4 *Assessment of historic stock parameters*

#### 1.12.4.1 Method 1: Stock-Production Model

***Justification***

The analysis was performed using the ASPIC.5 software (A Stock-Production model Incorporating Covariates) (Prager, 1994, 2005) assuming a Schaefer (1954) model. This program implements a non-equilibrium, continuous-time, observation-error estimator for the dynamic production model (Schnute, 1977; Prager, 1994). The model was used to estimate *r* (the intrinsic rate of population growth), MSY, the ratios of both current biomass or F to the biomass or F at which MSY can be attained, and q (the catchability coefficient, the proportion of total stock removed by one unit of fishing effort).

***Input parameters***

Input data consist in 4 sets of time series from 1964 to 2007 of total landings (in tons) and fishing effort expressed as days fishing x HP. Data regards landings and effort related to trawling, purse seining, beach seines and other small scale fisheries mostly including set nets. No information was available in order to determine more detailed specific effort targeting the stock in question between each fishing strategy and hence for the analysis it was assumed that neither targets for each fishing technique nor areas did change along the studied period.

MEDITS trawls surveys estimates of the index of abundance between 1994 and 2008 were available but the series was incomplete, shows high fluctuating values and the number of individuals measured by year is too low for being included in this analysis. For this reason, no analysis based on survey data was performed even though an attempt of including such information in the analysis was done. Such attempt resulted unsuccessful because lacking of enough correlation with the cpue's time series.

Considering the lower importance of beach seines and purse seines in the overall catch and also that the stocks in question were not the target of such fisheries, a lower weight were assigned to the information proceeding from such fisheries for the computations. As a setting option of ASPIC, priority (more weight) was assigned to the information on landings than to effort, considered the last measured with lower precision.

Several models were tested (Schaefer, Fox, Generalized), but the only that supplied fairly good fittings and reasonable results was the logistic Schaefer model. From the bootstrap results, bias-corrected (BC) confidence intervals were computed by standard methods (Efron and Gong 1983). 1000 bootstrap trials were performed computing 90% confidence intervals.

**Table 1.12.4.2. ASPIC input parameters of the FIT mode for GSA 22 & 23.**

| **B1/K** | **MSY** | **Range of MSY** | **K** | **Range of K** | **Fishing fleet** | **q (mean (CPUE) / 2*max(Y))** |
|---|---|---|---|---|---|---|
| 0. 5 | 1.10E+03 | 4.00E+02 to 3.00E+03 | 1.30E+04 | 5.00E+03 to 3.000E+04 | Trawlers<br>Purse seine<br>Beach seine<br>Small scale | 5.111E-09<br>6.063E-08<br>5.844E-08<br>4.213E-08 |

### *Results*

The main results of the analysis for the GSA22&23 are shown in the following table:

| **Model** | **MSY (tons)** | **$B_{MSY}$ (tons)** | **$F_{MSY}$** | **$f_{MSY}$ Beach seine** | **$f_{MSY}$ Trawl** | **$f_{MSY}$ Purse seine** | **$f_{MSY}$ Small scale** |
|---|---|---|---|---|---|---|---|
| **Logistic** | 1912 | 6604 | 0.289 | **1.426E+08** | **2.061E+08** | **4.776E+08** | **9.309E+07** |

| **Model** | **MSY** | | | **$F_{MSY}$** | | |
|---|---|---|---|---|---|---|
| | **80% lower** | | **80% higher** | **80% lower** | | **80% higher** |
| **Logistic** | 1731 | 1912 | 2189 | 0.249 | 0.289 | 0.321 |

MANAGEMENT and DERIVED PARAMETER ESTIMATES -----------------------------------------------------------------------------------------------------
-----------------

| Parameter | | Estimate | | |
|---|---|---|---|---|
| **B./Bmsy** | **Ratio: B(2008)/Bmsy** | **8.844E-01** | ---- | ---- |
| **F./Fmsy** | **Ratio: F(2007)/Fmsy** | **1.121E+00** | ---- | ---- |
| r | | 0.578 | | |

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)
-------------------------------------------------------------------------------------------------------------------------

| Obs | Year or ID | Estimated total F mort | Estimated starting biomass | Estimated average biomass | Observed total yield | Model total yield | Estimated surplus production | Ratio of F mort to Fmsy | Ratio of biomass to Bmsy |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1964 | 0.031 | 2.159E+04 | 1.860E+04 | 5.825E+02 | 5.825E+02 | -4.489E+03 | 1.081E-01 | 3.269E+00 |
| 2 | 1965 | 0.044 | 1.652E+04 | 1.532E+04 | 6.767E+02 | 6.767E+02 | -1.435E+03 | 1.525E-01 | 2.501E+00 |
| 3 | 1966 | 0.060 | 1.441E+04 | 1.376E+04 | 8.233E+02 | 8.233E+02 | -3.373E+02 | 2.066E-01 | 2.181E+00 |
| 4 | 1967 | 0.052 | 1.324E+04 | 1.295E+04 | 6.730E+02 | 6.730E+02 | 1.436E+02 | 1.794E-01 | 2.006E+00 |
| 5 | 1968 | 0.064 | 1.272E+04 | 1.249E+04 | 8.044E+02 | 8.044E+02 | 3.928E+02 | 2.224E-01 | 1.925E+00 |
| 6 | 1969 | 0.068 | 1.230E+04 | 1.216E+04 | 8.295E+02 | 8.295E+02 | 5.602E+02 | 2.356E-01 | 1.863E+00 |
| 7 | 1970 | 0.062 | 1.203E+04 | 1.198E+04 | 7.470E+02 | 7.470E+02 | 6.455E+02 | 2.153E-01 | 1.822E+00 |
| 8 | 1971 | 0.063 | 1.193E+04 | 1.190E+04 | 7.475E+02 | 7.475E+02 | 6.834E+02 | 2.169E-01 | 1.807E+00 |
| 9 | 1972 | 0.064 | 1.187E+04 | 1.184E+04 | 7.617E+02 | 7.617E+02 | 7.099E+02 | 2.221E-01 | 1.797E+00 |
| 10 | 1973 | 0.068 | 1.182E+04 | 1.178E+04 | 7.960E+02 | 7.960E+02 | 7.357E+02 | 2.332E-01 | 1.789E+00 |
| 11 | 1974 | 0.073 | 1.176E+04 | 1.171E+04 | 8.598E+02 | 8.598E+02 | 7.701E+02 | 2.536E-01 | 1.780E+00 |
| 12 | 1975 | 0.080 | 1.167E+04 | 1.160E+04 | 9.340E+02 | 9.340E+02 | 8.165E+02 | 2.780E-01 | 1.767E+00 |
| 13 | 1976 | 0.090 | 1.155E+04 | 1.147E+04 | 1.032E+03 | 1.032E+03 | 8.762E+02 | 3.108E-01 | 1.749E+00 |
| 14 | 1977 | 0.082 | 1.139E+04 | 1.138E+04 | 9.342E+02 | 9.342E+02 | 9.115E+02 | 2.834E-01 | 1.725E+00 |
| 15 | 1978 | 0.088 | 1.137E+04 | 1.133E+04 | 9.984E+02 | 9.984E+02 | 9.311E+02 | 3.042E-01 | 1.722E+00 |
| 16 | 1979 | 0.086 | 1.130E+04 | 1.129E+04 | 9.730E+02 | 9.730E+02 | 9.491E+02 | 2.976E-01 | 1.712E+00 |
| 17 | 1980 | 0.095 | 1.128E+04 | 1.123E+04 | 1.072E+03 | 1.072E+03 | 9.750E+02 | 3.296E-01 | 1.708E+00 |
| 18 | 1981 | 0.101 | 1.118E+04 | 1.113E+04 | 1.120E+03 | 1.120E+03 | 1.016E+03 | 3.477E-01 | 1.693E+00 |
| 19 | 1982 | 0.110 | 1.108E+04 | 1.100E+04 | 1.210E+03 | 1.210E+03 | 1.065E+03 | 3.799E-01 | 1.678E+00 |
| 20 | 1983 | 0.116 | 1.093E+04 | 1.086E+04 | 1.261E+03 | 1.261E+03 | 1.119E+03 | 4.012E-01 | 1.656E+00 |
| 21 | 1984 | 0.150 | 1.079E+04 | 1.059E+04 | 1.588E+03 | 1.588E+03 | 1.215E+03 | 5.179E-01 | 1.634E+00 |
| 22 | 1985 | 0.201 | 1.042E+04 | 1.007E+04 | 2.024E+03 | 2.024E+03 | 1.384E+03 | 6.938E-01 | 1.578E+00 |
| 23 | 1986 | 0.283 | 9.779E+03 | 9.231E+03 | 2.616E+03 | 2.616E+03 | 1.606E+03 | 9.785E-01 | 1.481E+00 |
| 24 | 1987 | 0.216 | 8.769E+03 | 8.687E+03 | 1.876E+03 | 1.876E+03 | 1.722E+03 | 7.459E-01 | 1.328E+00 |
| 25 | 1988 | 0.244 | 8.615E+03 | 8.454E+03 | 2.063E+03 | 2.063E+03 | 1.762E+03 | 8.426E-01 | 1.304E+00 |
| 26 | 1989 | 0.315 | 8.314E+03 | 7.952E+03 | 2.507E+03 | 2.507E+03 | 1.831E+03 | 1.089E+00 | 1.259E+00 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 27 | 1990 | 0.277 | 7.638E+03 | 7.528E+03 | 2.083E+03 | 2.083E+03 | 1.875E+03 | 9.557E-01 | 1.157E+00 |
| 28 | 1991 | 0.297 | 7.430E+03 | 7.285E+03 | 2.164E+03 | 2.164E+03 | 1.892E+03 | 1.026E+00 | 1.125E+00 |
| 29 | 1992 | 0.326 | 7.157E+03 | 6.964E+03 | 2.270E+03 | 2.270E+03 | 1.906E+03 | 1.126E+00 | 1.084E+00 |
| 30 | 1993 | 0.275 | 6.793E+03 | 6.813E+03 | 1.873E+03 | 1.873E+03 | 1.911E+03 | 9.492E-01 | 1.029E+00 |
| 31 | 1994 | 0.434 | 6.831E+03 | 6.373E+03 | 2.764E+03 | 2.764E+03 | 1.907E+03 | 1.497E+00 | 1.034E+00 |
| 32 | 1995 | 0.496 | 5.975E+03 | 5.507E+03 | 2.733E+03 | 2.733E+03 | 1.857E+03 | 1.714E+00 | 9.047E-01 |
| 33 | 1996 | 0.442 | 5.098E+03 | 4.898E+03 | 2.167E+03 | 2.167E+03 | 1.784E+03 | 1.528E+00 | 7.720E-01 |
| 34 | 1997 | 0.484 | 4.715E+03 | 4.477E+03 | 2.168E+03 | 2.168E+03 | 1.713E+03 | 1.672E+00 | 7.140E-01 |
| 35 | 1998 | 0.364 | 4.261E+03 | 4.319E+03 | 1.571E+03 | 1.571E+03 | 1.683E+03 | 1.256E+00 | 6.452E-01 |
| 36 | 1999 | 0.364 | 4.373E+03 | 4.423E+03 | 1.608E+03 | 1.608E+03 | 1.704E+03 | 1.255E+00 | 6.622E-01 |
| 37 | 2000 | 0.403 | 4.469E+03 | 4.427E+03 | 1.786E+03 | 1.786E+03 | 1.705E+03 | 1.393E+00 | 6.767E-01 |
| 38 | 2001 | 0.315 | 4.388E+03 | 4.540E+03 | 1.429E+03 | 1.429E+03 | 1.725E+03 | 1.087E+00 | 6.645E-01 |
| 39 | 2002 | 0.292 | 4.685E+03 | 4.868E+03 | 1.423E+03 | 1.423E+03 | 1.780E+03 | 1.009E+00 | 7.094E-01 |
| 40 | 2003 | 0.308 | 5.042E+03 | 5.162E+03 | 1.588E+03 | 1.588E+03 | 1.821E+03 | 1.062E+00 | 7.635E-01 |
| 41 | 2004 | 0.291 | 5.275E+03 | 5.416E+03 | 1.577E+03 | 1.577E+03 | 1.850E+03 | 1.005E+00 | 7.988E-01 |
| 42 | 2005 | 0.291 | 5.549E+03 | 5.665E+03 | 1.649E+03 | 1.649E+03 | 1.874E+03 | 1.005E+00 | 8.402E-01 |
| 43 | 2006 | 0.311 | 5.774E+03 | 5.813E+03 | 1.809E+03 | 1.809E+03 | 1.885E+03 | 1.075E+00 | 8.743E-01 |
| 44 | 2007 | 0.325 | 5.850E+03 | 5.845E+03 | 1.897E+03 | 1.897E+03 | 1.887E+03 | 1.121E+00 | 8.858E-01 |
| 45 | 2008 | | 5.840E+03 | | | | 8.844E-01 | | |

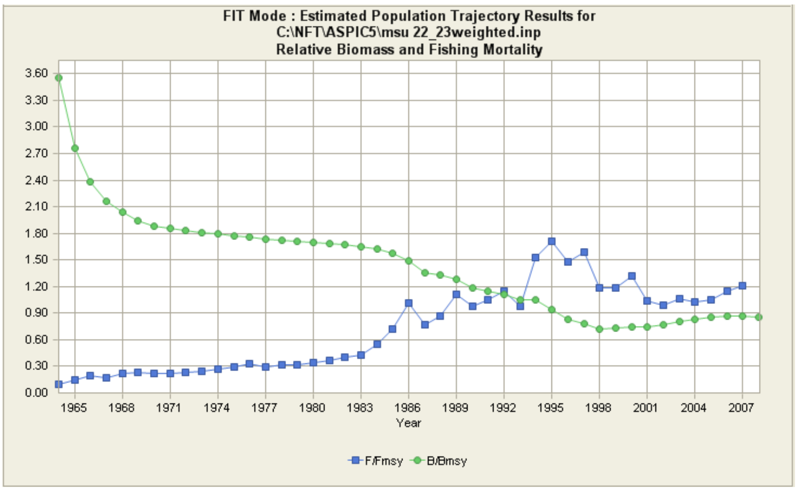



**Fig.1.12.4.3. F/$F_{MSY}$ and B/$B_{MSY}$ estimated for each year with the logistic Schaefer model.**

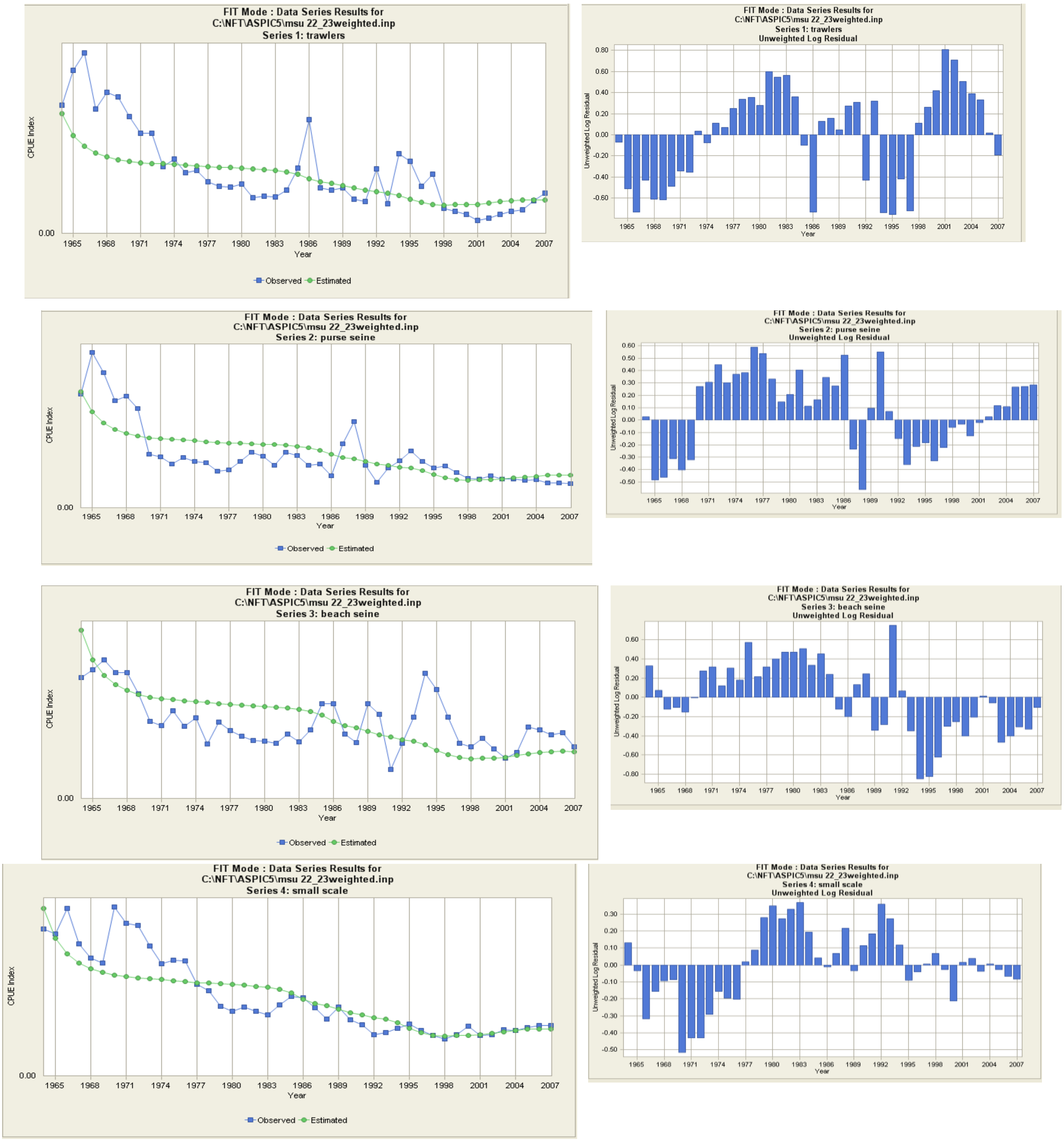



**Fig 1.12.4.4. Model fitting for each gear/strategy and model residuals.**

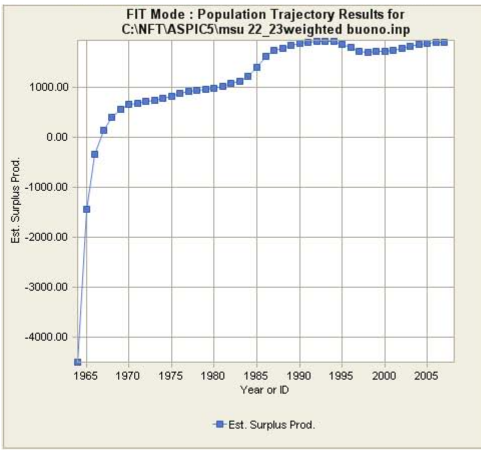



**Fig.1.12.4.5. Estimated surplus production of *Mullus surmulletus* in GSA 22&23 using the Logistic Schaefer model for the period 1964-2008.**

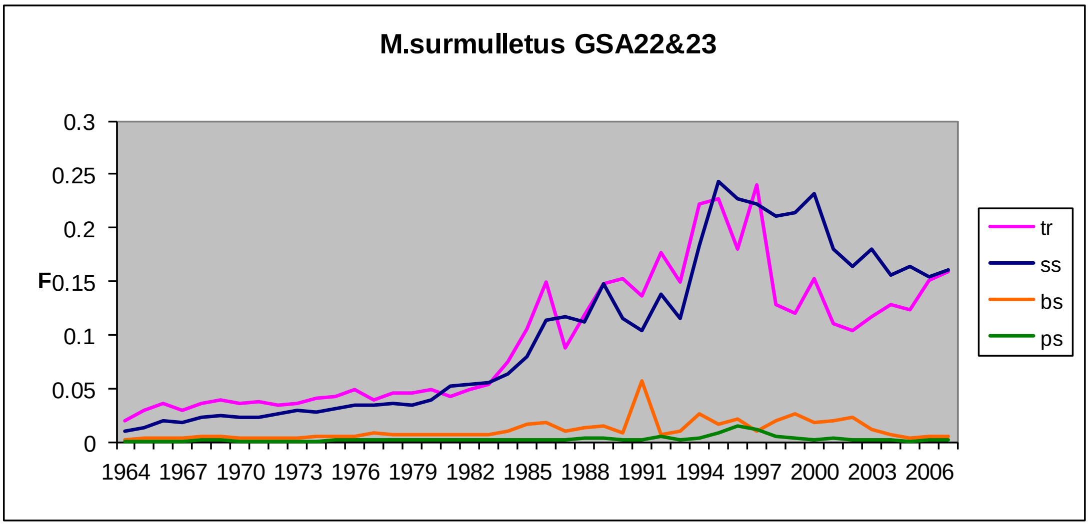



**Fig.1.12.4.6. F vector by gear for *Mullus surmuletus* in GSA20 (tr (trawlers); ss (small-scale); bs (beach seines); ps (purse seiners)).**

The results of the ASPIC runs are presented in Figures 1.12.4.3-6. The stock of striped red mullet in GSA22&23 in 2007 can be considered overexploited (current $F_{curr}/F_{MSY}$=1.12 and the current biomass is below $B_{MSY}$ ($B/B_{MSY}$ = 0.88). A value of $F_{MSY}$ of 0.29 was estimated while the model estimated for the more recent year (2007) a value of $F$ of about 0.33.

### 1.12.4.2 Method 2: SURBA

***Justification***

The relatively long time series of data available from the MEDITS surveys provided the most useful data set to analyse the trend of *Mullus surmuletus* stock in GSAs 22&23. The MEDITS indices of abundance (n/hour) for red mullet in GSA 22-23, covering the period 1994-2008 (except years 2002 and 2007) were analysed using SURBA (Survey-Based stock Assessment approach, Needle, 2003). The annual standardized size distributions (1 cm total length class, Fig. 1.10.4.7) from MEDITS were converted in age distributions using L2AGE4 software (Fig. 1.10.4.8).

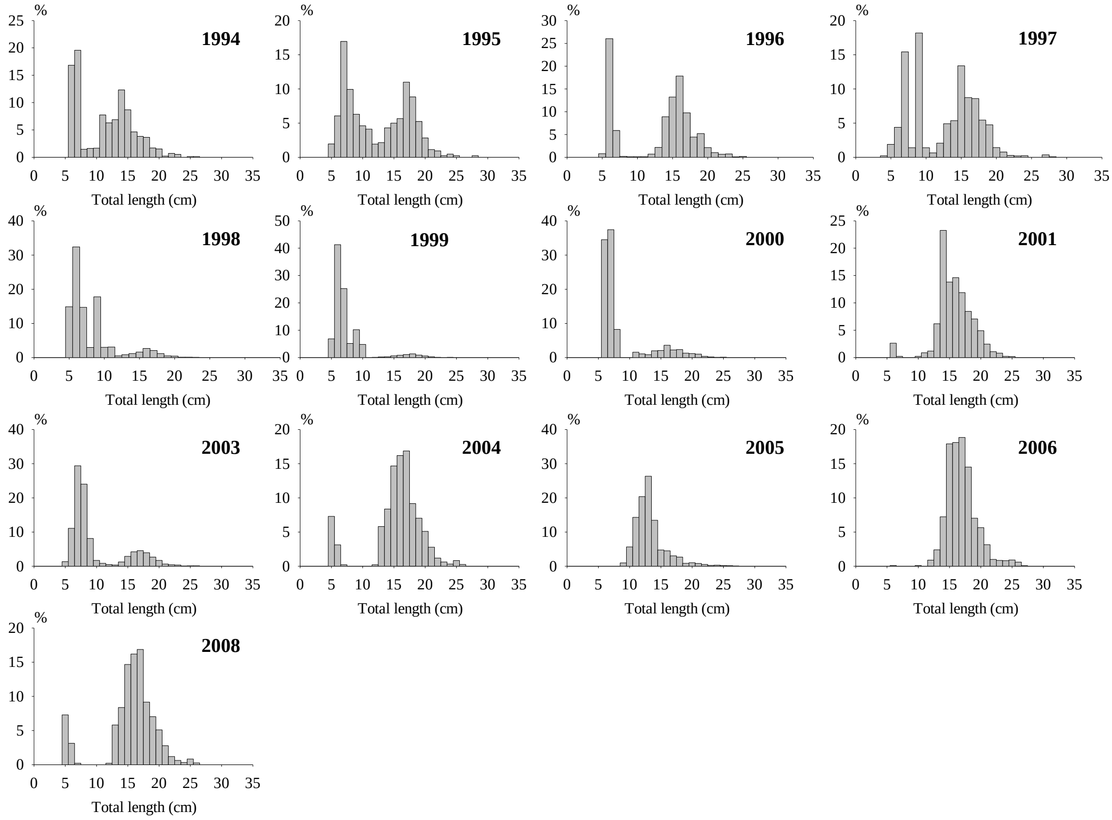


**Fig. 1.12.4.7. MEDITS length frequency distributions of red mullet in the GSAs 22&23.**

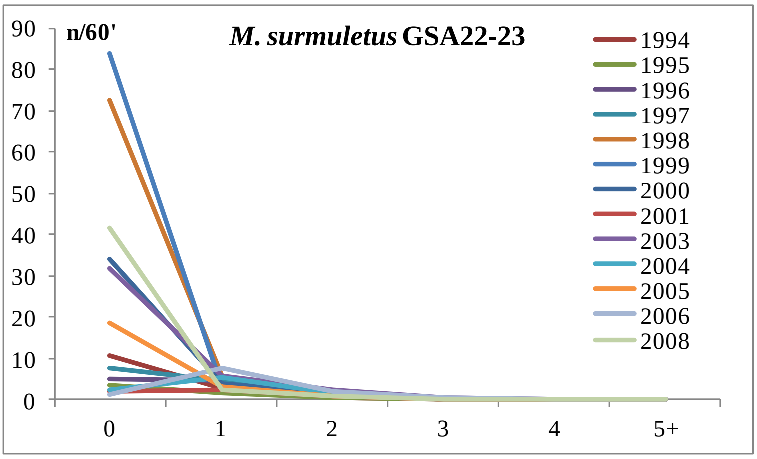



**Fig. 1.12.4.8. Numbers at age distributions of red mullet or MEDITS 1994-2008 in GSAs 22&23.**

***Input parameters***

Table 1.12.4.3 shows the input parameters used to run SURBA. The biological parameters are the same as those used for GSA 05.

Single survey exploratory SURBA 2.2 model runs were carried out with the following settings:
Year range: 1994-2008, 2002 and 2007 lacking
Age range: 0-5+

Age weighting: 02 (ages 0), 0.6 (ages 1), 1 (ages 2-5+)
Catchability: 0.4 (age 0), 1 (age 1-2), 0.8 (age 3-4), 0-7 (age 5+)

**Table 1.12.4.3. Input parameters of SURBA.**

**Growth parameters**

| L∞ | k | t0 | a | b |
|---|---|---|---|---|
| 40.05 | 0.164 | -1.883 | 0.0084 | 3.118 |

**Proportion of mature**

| Age | | | | | |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5+ |
| 0.15 | 0.39 | 0.79 | 0.95 | 1 | 1 |

**Natural mortality**

| Age | | | | | |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5+ |
| 1 | 0.6 | 0.4 | 0.3 | 0.3 | 0.3 |

***Results***

Comparative scatterplots at age indicated a poor consistency of the MEDITS data between ages 0-2, 0-3 and 0-4, 1-3 and 1-4 (Fig. 1.12.4.9).

The trends in F, SSB and recruitment at age 0 from SURBA run, and the model residuals are given in Figures 1.12.4.10-11. The retrospectives for the MEDITS survey data are given in Figure 1.12.4.12. SURBA estimated large oscillations in the temporal effect for F. The cohort effect indicated certain increase in the recruitment. Total mortality (Z) showed oscillations, without a clear trend. F (bootstrapped estimates) also showed some oscillations. SSB showed oscillations, with a certain increasing trend. The residuals at age did not show any pattern.

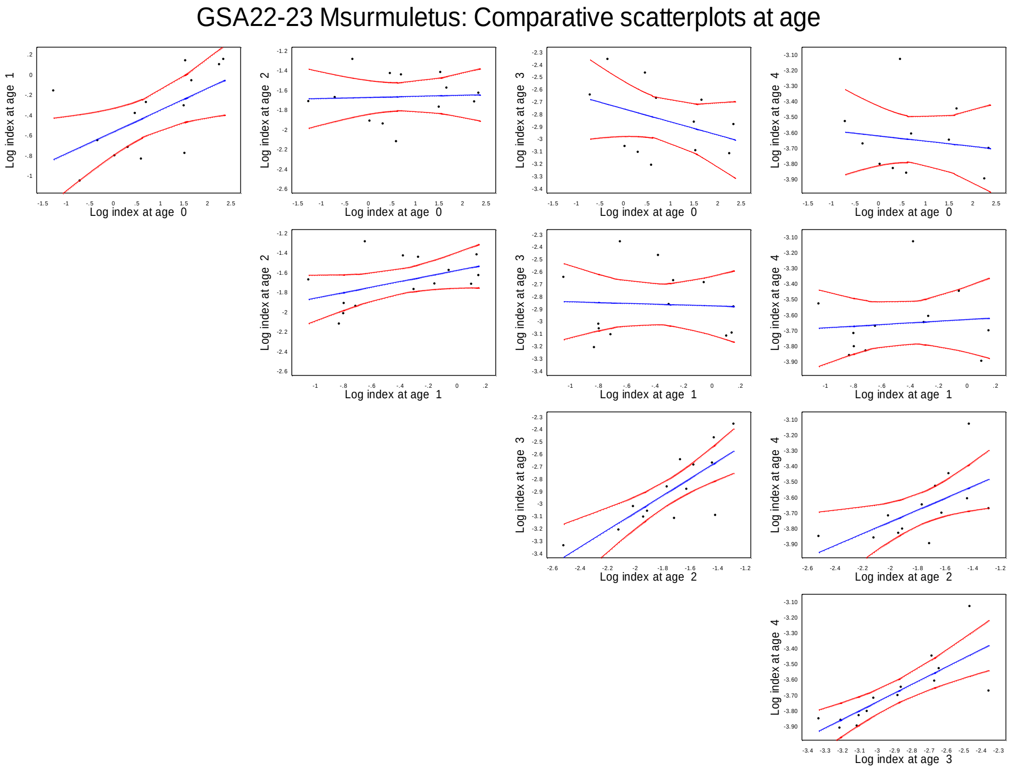



**Fig. 1.12.4.9. Striped mullet in GSAs 22&23: Output from SURBA plots for MEDITS survey, showing age scatter plots.**

A)

B)

C)

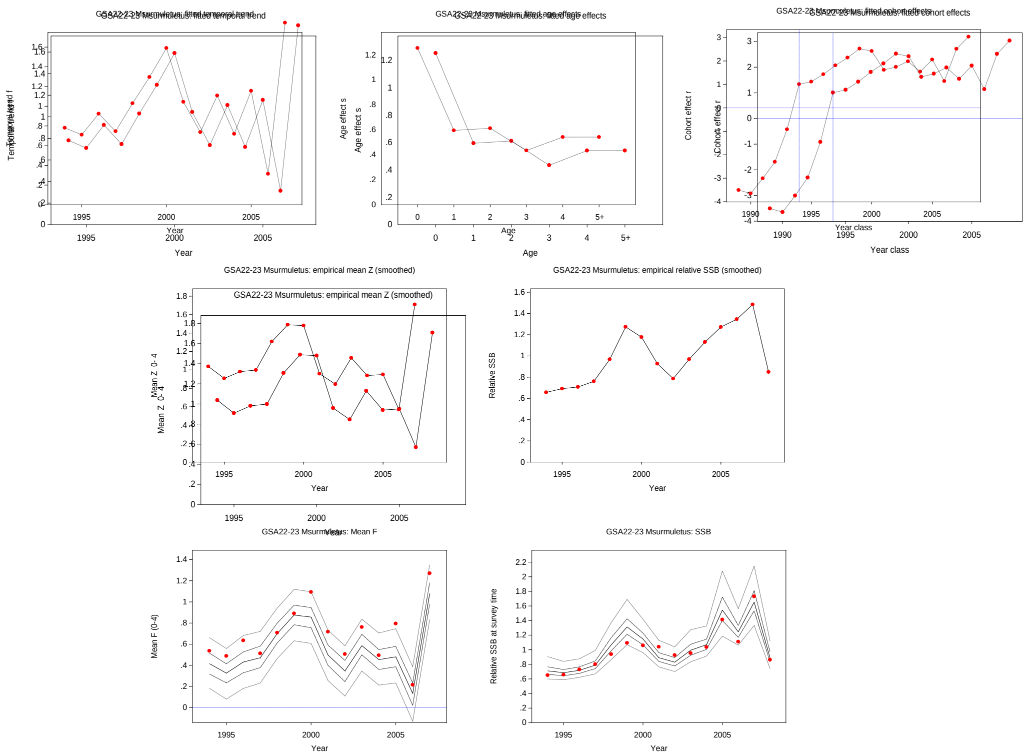
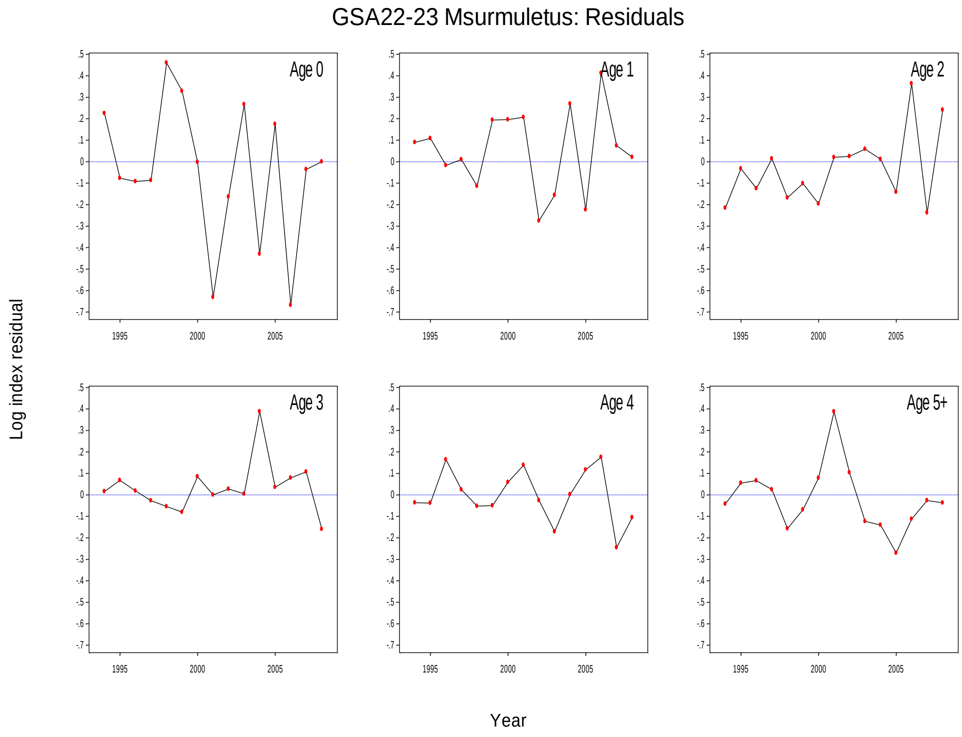



**Fig. 1.12.4.10. SURBA estimates for striped red mullet in GSAs 22&23. A) model parameters. B) total mortality and SSB C) bootstrapped (lines) and fitted (points) estimates of F and SSB, and empirical relative SSB, solid and dotted lines are respectively 50% and 5- 95% of bootstrapped estimates.**

A)




B)

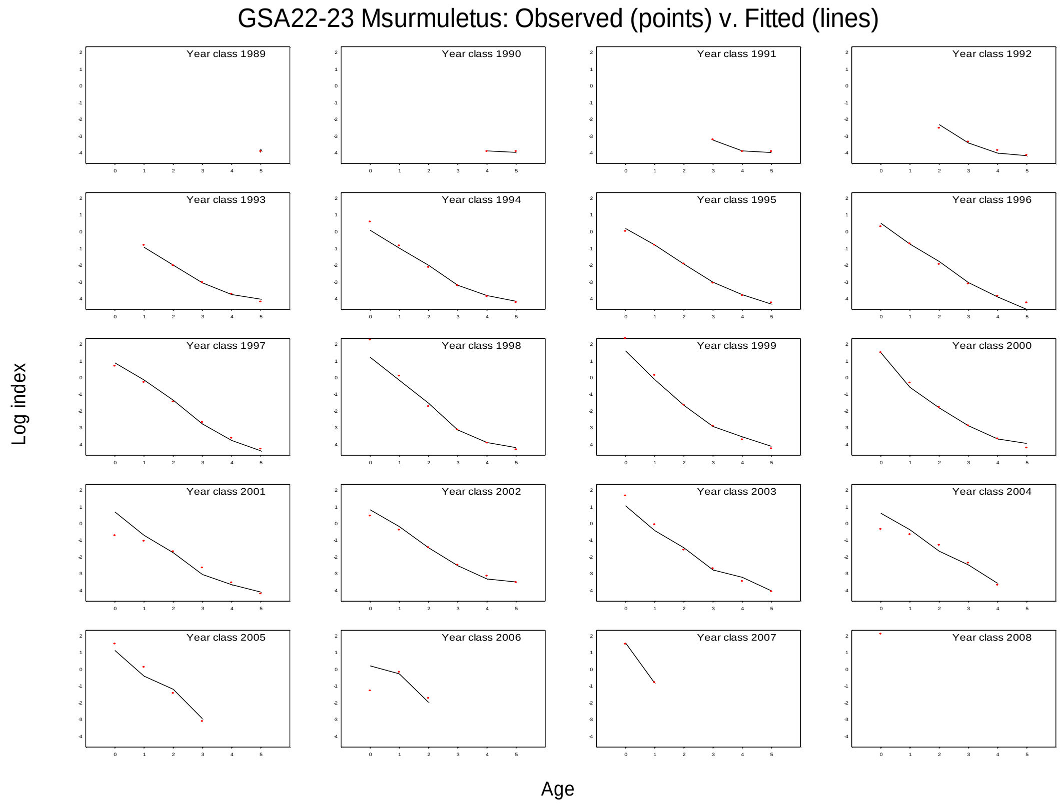



**Fig. 1.12.4.11. SURBA model diagnostic for striped red mullet in GSAs 22&23. A) Temporal trend in residuals by age B) Observed (points) and fitted (lines) year classes.**

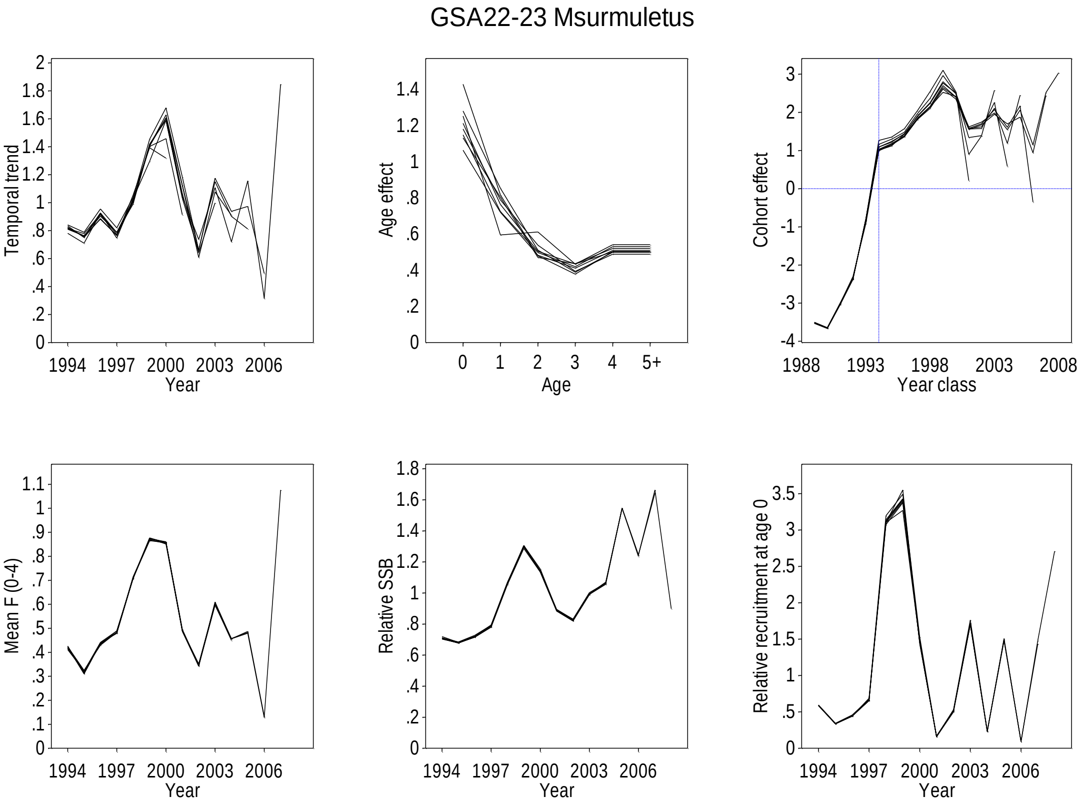



**Fig. 1.12.4.12. SURBA model of striped red mullet in GSAs 22&23: retrospective analysis.**

## 1.12.5 *Scientific advice*

### 1.12.5.1 Short term considerations

***State of the spawning stock size***

There are not agreed precautionary reference levels and hence is not possible to fully evaluate the status of the spawning stock size in respect to these. MEDITS survey indices show a variable pattern of abundance although very few individuals were sampled from 1994 to 2000. This is related to the unsuitability of the MEDITS survey for *Mullus surmulletus*, species that often can be found living in areas very close to the coast or on hard bottoms. However, the SSB as estimated by the SURBA shows a slight incresing trend over the time series.

The total biomass of the stock estimated with the production model using the logistic approach, is below the $B_{MSY}$, being the 20% of it ($B/B_{MSY}$ = 0.88).

***State of recruitment***

Recruitment as estimated by SURBA does not show any particular trend, with particular large year classes observed in 1998 and 2008.

***State of exploitation***

The current F as estimated by ASPIC is larger than the limit reference value ($F/F_{MSY}$= 1.12). The maximum values for F were found for the years 1994-2004, while a decline in F was observed in the more recent years. Thus, striped red mullet in GSA 22&23 is considered exploited unsustainably. SURBA show a stable F with a peak in the last year (2008) but in general without a clear trend.

#### 1.12.5.2 Data quality and availability

No data of the size structure of the catches from striped red mullet was available for GSAs 22&23 from DCR.

Data used in ASPIC proceed from a reconstruction of landings derived from different sources. A number of gaps and inconsistencies can be found. The main problems regards the quality of effort information, in particular the availability of information on total effort only by type of gear or group of gears without any distinction by métier. For species that shows a limited bathymetric distribution related to the fleet operational area as *Mullus surmulletus*, the lack of such information does not allow to quantify which is the real amount of effort directed to the species in question, having the bathymetric distribution of fishing fleets (i.e. trawlers) more wider depth range. Moreover, no data on discards is available.

This lack of more precise information obliged to use the overall effort by gear assuming that the pattern of spatial distribution and target of the fleets remained almost unchanged along the analysed period and also the discards rate. Only in this way it is possible to assume that the observed changes in abundance (cpue) are mainly due to changes in fishing pressure on the stock in question.

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## 1.13 **Stock assessment of hake in GSA 20**

### 1.13.1 *Stock identification and biological features*

#### 1.13.1.1 Stock Identification

Hake is one of the most important fish stock in GSA 20 for bottom trawlers, nets (mainly gill nets) and longlines. The stock is distributed in depth between 50-600 m, with a peak in abundance in depths between 200 and 300 m. The stock is exploited almost exclusively by the Greek fishing fleet. Spawning takes place all year around, with a peak during winter and spring.

#### 1.13.1.2 Growth

Biological sampling was conducted in 4 fishing ports, which are the main landing ports of GSA 20. Landings from trawlers, nets and hooks were included in biological sampling. Sampling was conducted during different seasons, depending on the species life cycle, the size of local production and the temporal or spatial restrictions on the use of fishing gears.

The growth parameters for hake for each sex are given for GSA 20 in Figure 1.13.1.1. The age interpretation was done by otoliths reading. Sampling was conducted from 2003 to 2005.

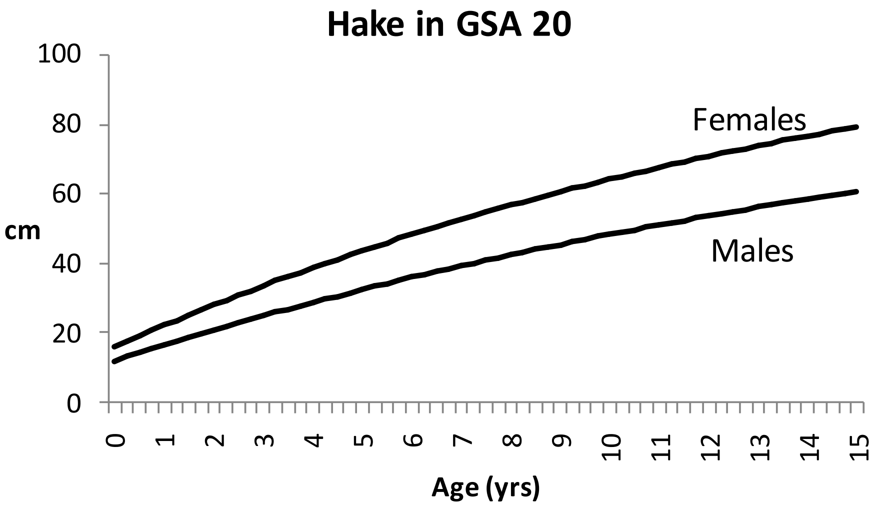



**Fig. 1.13.1.1. Growth curves of male and female hake in GSA 20.**

SGMED 08-04 agreed however to adopt the fast growth curve (Tab. 1.13.1.1), as calculated in the Gulf of Lions by Mellon Duval et al. (2010), to assess hake in GSA 20.

**Table 1.13.1.1. Growth parameters of hake according to the French tagging experiments (from Mellon-Duval et al., 2010).**

| HAKE | $L_\infty$ (cm) | k | $t_0$ |
|---|---|---|---|
| F+M | 110 | 0.178 | 0 |

The natural mortality at age vector for hake in GSA 20 , as estimated using these growth parameters with the Prodbiom method (Abella et al., 1997), is showed in Table 1.13.1.2.

**Table 1.13.1.2. Natural mortality vector for hake in GSA 20.**

| M at age | | | | | |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5+ |
| 1.17 | 0.67 | 0.56 | 0.52 | 0.50 | 0.3 |

#### 1.13.1.3 Maturity

In the Ionian Sea females attain the length of first maturity at 36 cm total length (Stergiou *et al*., 1997). Based on this information and considering the growth pattern we calculated the proportion of mature specimenns at age showed in Table 1.13.1.3.

**Table 1.13.1.3. Proportion of mature hake at age in GSA 20.**

| Mature at age | | | | | |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5+ |
| 0 | 0.3 | 0.75 | 1 | 1 | 1 |

### 1.13.2 *Fisheries*

#### General description of fisheries

Hake mainly lives on muddy substrates in depths between 50-600 m. The main landing port in the area is the port of Patras. Other important landing ports are in Igoumenitsa, Kerkyra, Preveza, Killini and Kalamata.

The bottom trawl fishery in Greece is a mixed fishery, operating 24hr per day. Bottom trawl fishing targeting hake, is taking place mainly during the day in muddy bottoms in 80-400 m depth. Since the October 2001 the mish size of the cod-end net of bottom trawls has been increased according to European Regulation (ER 2550/2000) and National Law (N B 20/16-1-2001) to 40 mm. Apart from hake, important target species are shrimps, anglerfish, blue whiting, megrims, picarel and red mullet.

The gill nets are setting in the morning and are hauling the next day in depth from 80-300 m. The mesh size used is about 48 to 64 mm. The fishery is carried out mainly during summer when bottom trawl fishery is prohibited. Long line fishery for hake is taking place in deeper waters down to 500 m mainly during summer. Fishing is taking place during the day. The size of the hook is no. 6-8. Gillnet and especially longline fisheries have a relatively greater species and size selectivity. The main by catch species in the gill net fishery is horse mackerel.

Due to the selectivity of each gear the length composition differs significantly. The catch from bottom trawls consists mainly of small individuals (hake of 6-18 cm of length are ~75% of the catch by number). The catch of gill nets comprises mainly of specimens with lengths between 20 and 40 cm, while longliners catch relatively large fish.

There was a general declining trend in the number of vessels in recent years in all fleet segments. Capacity generally declined, except in trawlers that had a peak of capacity in 1997, which then declined to approximately the same levels as in 1991. The average length slightly increased in all fleet segments, except boat seiners. Average age substantially declined in all fleet segments except boat seiners where average age remained stable and was the highest among all fishing fleets. This is attributed to the exclusion of beach-seines from all European funding, which leaded to the modernization of all Greek fishing vessels, that is started in 1987 and will end with the complete banning of fishing with this tool in 2013 (ER 1967/2006).

There was a general declining trend in the number of vessels in recent years in all fleet segments. Capacity generally declined, except in trawlers that had a peak of capacity in 1997, which then declined to approximately the same levels as in 1991. The average length slightly increased in all fleet segments, except boat seiners. Average age substantially declined in all fleet segments except boat seiners where average age remained stable and was the highest among all fishing fleets.

#### 1.13.2.1 Management regulations applicable in 2007 and 2008

RD 917/1966 is the principal law regulating the operation of trawlers. Although this law is still in effect, it has been superseded by EC Regulation 1626/1994, and its replacement Regulation 1967/2006. The main restrictions established by Greek and European legislation are:

(1) establishment of a total exclusion zone one and a half mile from the coastline of the mainland and the islands,
(2) a total fishing ban from the 1st of June till the end of September,
(3) establishment of a total exclusion zone which is: either a zone three miles from the coastal line or a zone shallower than 50 m,
(4) minimum cod-end mesh size is 40 mm (EC regulation 1967/2006); from 1 July 2008, the net shall be replaced by a square-meshed net of 40 mm at the cod-end or, at the duly justified request of the ship owner, by a diamond meshed net of 50 mm.

Additional restrictions exist for bottom trawling in specific areas: in Amvrakikos Gulf and some parts of the Korinthiakos Gulf and the Ionian Sea, trawling is prohibited all year around, while in Patraikos Gulf trawling is prohibited from the 1st of March till the end of November and in the entire Korinthiakos is prohibited from from the 1$^{st}$ of April till the end of November (Presidential Decree 698/81).

The operation of the bottom set nets is subject to the following main restrictions:
(1) the maximum total length of the trammel net is 6000 m.
(2) the minimum mesh size opening is 16 mm.
(3) monofilament or twine diameter of the net should not exceed 0.5 mm.
(4) the maximum drop of a combined trammel and gill net should not exceed 10 m and the length of combined nets should not exceed 2500 m.

For the bottom longlines the only restriction derives from ER 1967/2006 and referred to maximum number of hooks per fishers (1000 hooks) and the total maximum number of hooks per vessel (5000 hooks)

### 1.13.2.2 Catches

***Landings***

Estimation of landings was based on random sampling in 66 sampling stations (ports) in GSA 20. Sampling was conducted on a monthly basis at each sampling station, where a sufficient number of vessels from each fleet segment and gear type was randomly selected and landings by species recorded. Based on these data, average landings per fishing day, by species and for each fishing gear were estimated. Based on total effort estimations, sampled data were raised to the whole fleet to estimate total landings by species, fleet segment, fishing gear, and GSA.

The estimated landings of hake in GSA 20 are presented in Tab. 1.13.2.4. According to official data, the annual bottom trawl (OTB) landings ranged from 30 to 753 t, the landings of the trammel nets (GTR) ranged from 1370 to 3195 t, whereas the landings of the long lines (LLS) ranged from 73 to 295 t. The annual landings in 2008 was 3294 t.

**Tab. 1.13.2.4. Hake catches per gear and per year in GSA 20.**

| Year\Gear | SV | OTB | LLS | GTR | **Total** |
|---|---|---|---|---|---|
| 2003 | 11 | 307 | 73 | 1370 | **1761** |
| 2004 | 3 | 403 | 295 | 2796 | **3497** |
| 2005 | 0 | 515 | 207 | 3195 | **3917** |
| 2006 | 0 | 753 | 199 | 2568 | **3520** |
| 2008 | | 459 | 286 | 2545 | **3294** |

Overall, in 2008, 77% of the hake landings are attributed to trammel nets, 14% to bottom trawls, and 9% to long lines. The length frequency distribution of hake bottom trawl landings in GSA 20 is presented in Fig. 1.13.1.2. The modal length in 2004 was 15-19 cm, 13 cm in 2005and 19 cm in 2006. The proportion of the undersized landed specimens (<20 cm, according to 1967/2006 Regulation) was 61%, 71%, and 37%, for the years 2004, 2005 and 2006, respectively whereas the proportion of specimens with lengths >29 cm was 5%, 4% and 6% for the years 2004, 2005 and 2006, respectively (from SGMED 08-04).

Length data for long liners landings were provided for the years 2005, 2006 and 2008. LFD of trammel nets were available for the years 2004 and 2005 whereas LFD for OTB were lacking in 2005. The lengths of long line landings ranged from 23 cm to 69 cm. No undersized species were landed by long liners during these years whereas the proportion of the specimens larger than 29 cm was 97% and 95% in 2005 and 2006, respectively. The lengths of the nets landings ranged from 17 cm to 37 cm. A very small proportion of the landings consisted of undersized specimens.

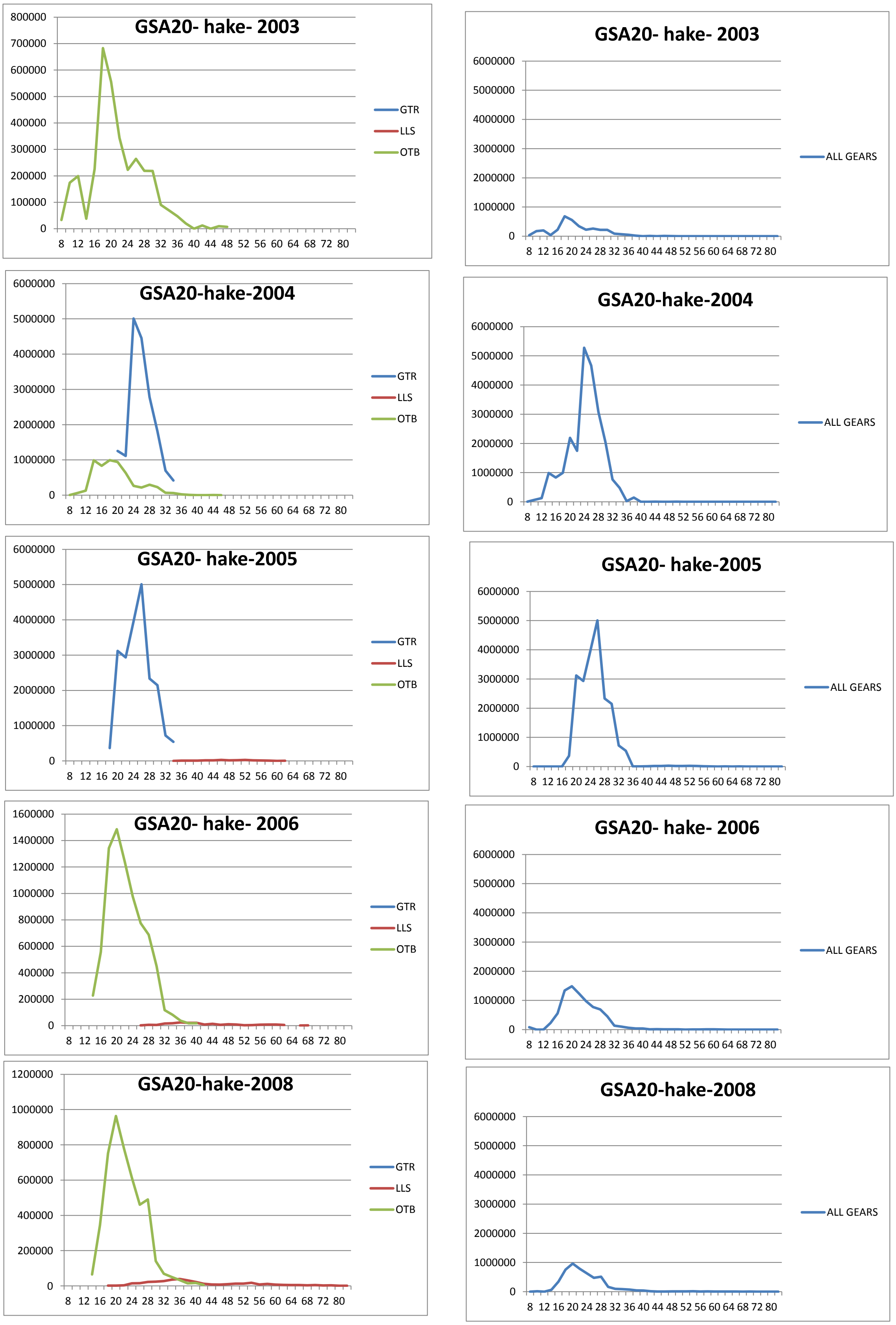



**Fig. 1.13.2.1. Length frequency distributions of hake landings in GSA 20 by gear and year.**

### *Discards*

In Greece, the discards and landings of trawlers, purse-seiners, coastal vessels, and drifting longliners were estimated based on board sampling. Three times every year, sampling was conducted in GSA 20. Each time, catch, discards, and landings were recorded for each gear type and fleet segment. Based on this sampling, total discards were estimated by species and gear type.

Discards of hake in bottom trawl fishery in GSA 20 were < 30 t in all years for both fleet segments (SGMED-08-03). The proportion of discards to catch ranged from 0.05 to 0.8. An extremely high value for hake discards from gill nets was reported in 2005 (679 t discards). This value can't be considered as a real one and is probably due to misreporting or typing errors in data entry.

No length distribution of discards was available.

### *Fishing effort*

A description of the data collection system for fishing effort in GSA 20 was provided in SGMED 08-03. Estimation of effort was based on interviews conducted with random sampling in 30 sampling stations (ports) in GSA 20. Sampling was conducted on a monthly basis at each sampling station, where a sufficient number of vessels from each fleet segment and gear type were randomly selected and effort was recorded. In addition, all fishing vessels present in the sampling stations were categorized as full-time, part-time, occasionally fishing, or inactive and the proportion of the year when they were active was estimated. Based on this information, sampled data were raised to the whole fleet to estimate total effort per fleet segment, and fishing gear. It should be noted that the estimated effort do not refer to the effective effort targeting to hake but to the entire effort of each fleet segment. This is very important for the long lines and gill nets because the effort targeting hake is much smaller than the effort of the fleets.

The fishing effort of the vessel using trammel nets LOA<12 m and of the bottom trawls 12-24 m showed a significant reduction in GSA 20 from 2003 to 2008 (Fig. 1.13.2.2).

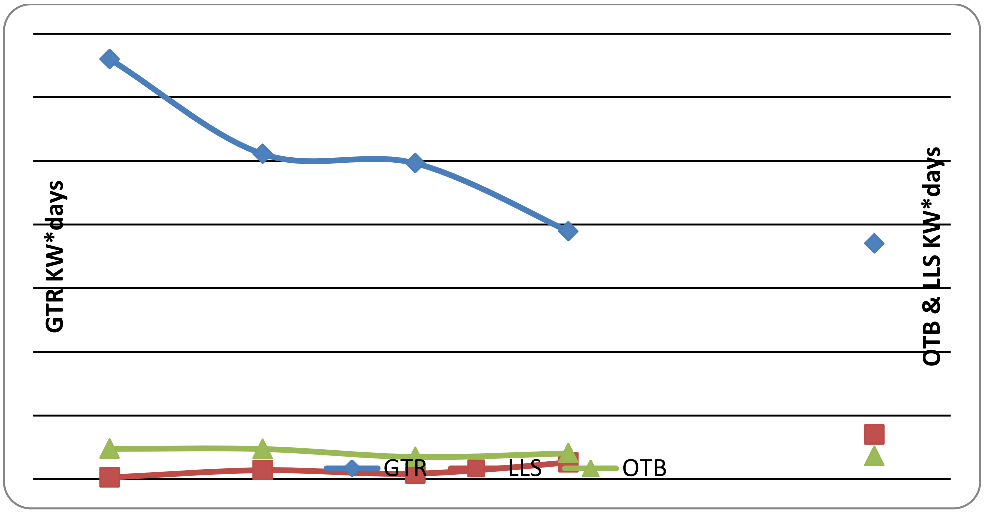



**Fig.1.13.2.2. Trends in relative (to 2003) fishing effort (kW*days at sea) in GSA 20.**

SGMED 08-04 considered the evaluation of the fishing effort of the main fishing gears in Ionian Sea difficult to be interpreted. For example, the effort of the nets decreased by 42% in 2006 in relations with the effort in 2003. Such a reduction is unlikely to be due to a decreasing of the number/power of the vessels.

### 1.13.3 *Scientific surveys*

#### 1.13.3.1 MEDITS

***Methods***

Tables TA, TB, TC were provided according to the MEDITS protocol. The MEDITS survey was carried out in GSA 20 every summer from 1994 to 2006, except in 2002 because of administrative problems. For similar reasons, no MEDITS survey was conducted in Greece in 2007. During 1994 and 1995 the survey in GSA 20 was carried out in a small number of stations (12 and 15). The number of stations kept increasing and in 1998 was more than doubled (32 stations). The survey vessel changed in 1998. Due to these changes in the survey design, caution is needed when investigating the trends of relevant indicators in the MEDITS time series. More details on methodology and trends on selected indicators may be found in MEDITS (2007).

Based on the DCR data call, abundance and biomass indices were recalculated and presented in section 11 of this report.

In GSA 20 the following number of hauls were reported per depth stratum (Tab. 1.13.3.1, Fig. 1.11.3.1).

**Tab. 1.13.3.1. Number of hauls per year and depth stratum in GSA 20, 1994-2006.**

| Stratum | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2003 | 2004 | 2005 | 2006 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 010-050 | 1 | 2 | 2 | 2 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 050-100 | 3 | 4 | 8 | 7 | 11 | 10 | 11 | 9 | 10 | 10 | 10 | 9 | 10 |
| 100-200 | 1 | 3 | 4 | 2 | 5 | 6 | 5 | 6 | 6 | 6 | 5 | 6 | 6 |
| 200-500 | 2 | 3 | 4 | 4 | 7 | 7 | 7 | 8 | 8 | 9 | 8 | 8 | 7 |
| 500-800 | 1 | 2 | 4 | 3 | 5 | 5 | 5 | 5 | 5 | 3 | 5 | 4 | 6 |
| TOTAL | 8 | 14 | 22 | 18 | 32 | 31 | 31 | 31 | 32 | 31 | 31 | 30 | 32 |

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

### *Geographical distribution patterns*

Fig. 1.13.3.1 shows the distribution of the trawl stations samplend during the MEDITS survey.

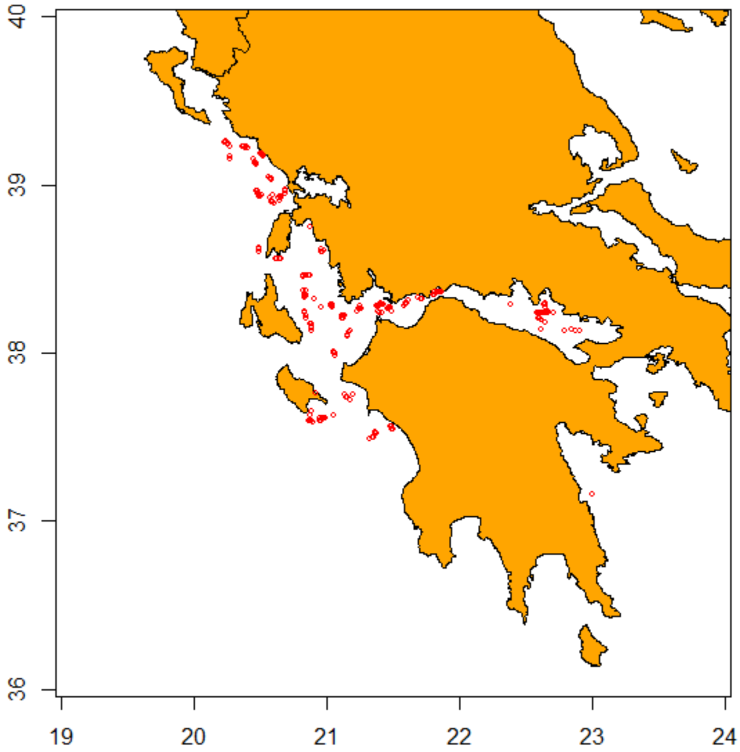



**Fig.1.13.3.1. Distribution of sampling hauls of the MEDITS survey in GSA 20.**

### *Trends in abundance and biomass*

Fishery independent information regarding the state of the hake in GSA 20 was derived from the international survey MEDITS. Figure 1.13.3.2 displays the estimated trend in hake abundance and biomass in GSA 20.

The estimated abundance and biomass indices reveal a significantly increased level of stock size since 2003. However, the recent abundance and biomass indices are subject to high variation (uncertainty).

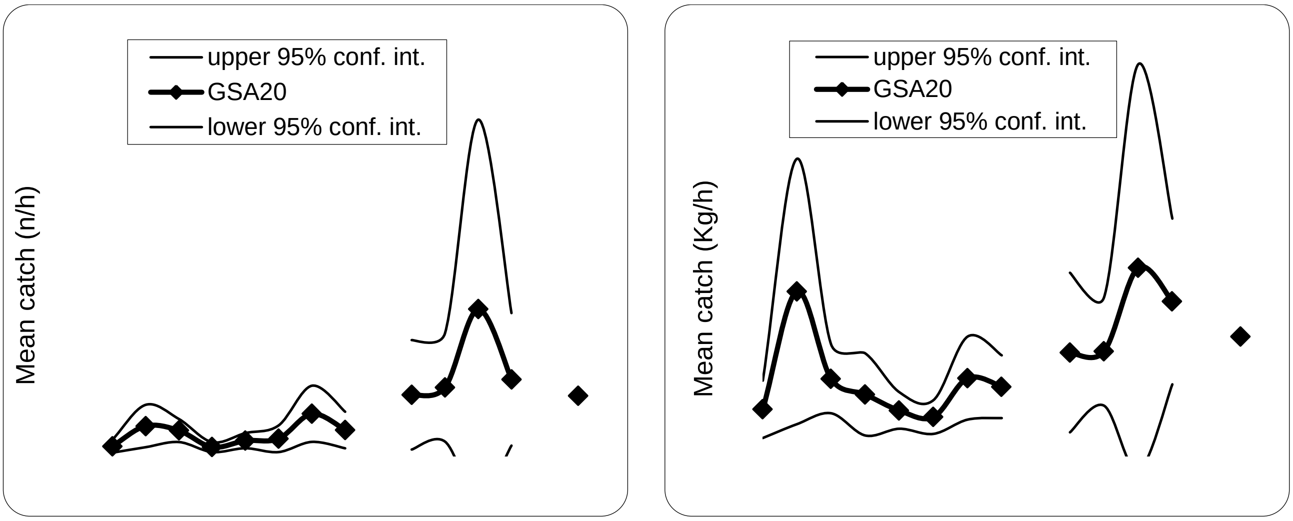



**Fig. 1.13.3.2. Abundance and biomass indices of hake in GSA 20.**

### *Trends in abundance by length or age*

The following Fig. 1.13.3.3-4 display the stratified abundance indices of GSA 20 in 1994-2001 and 2003-2007.

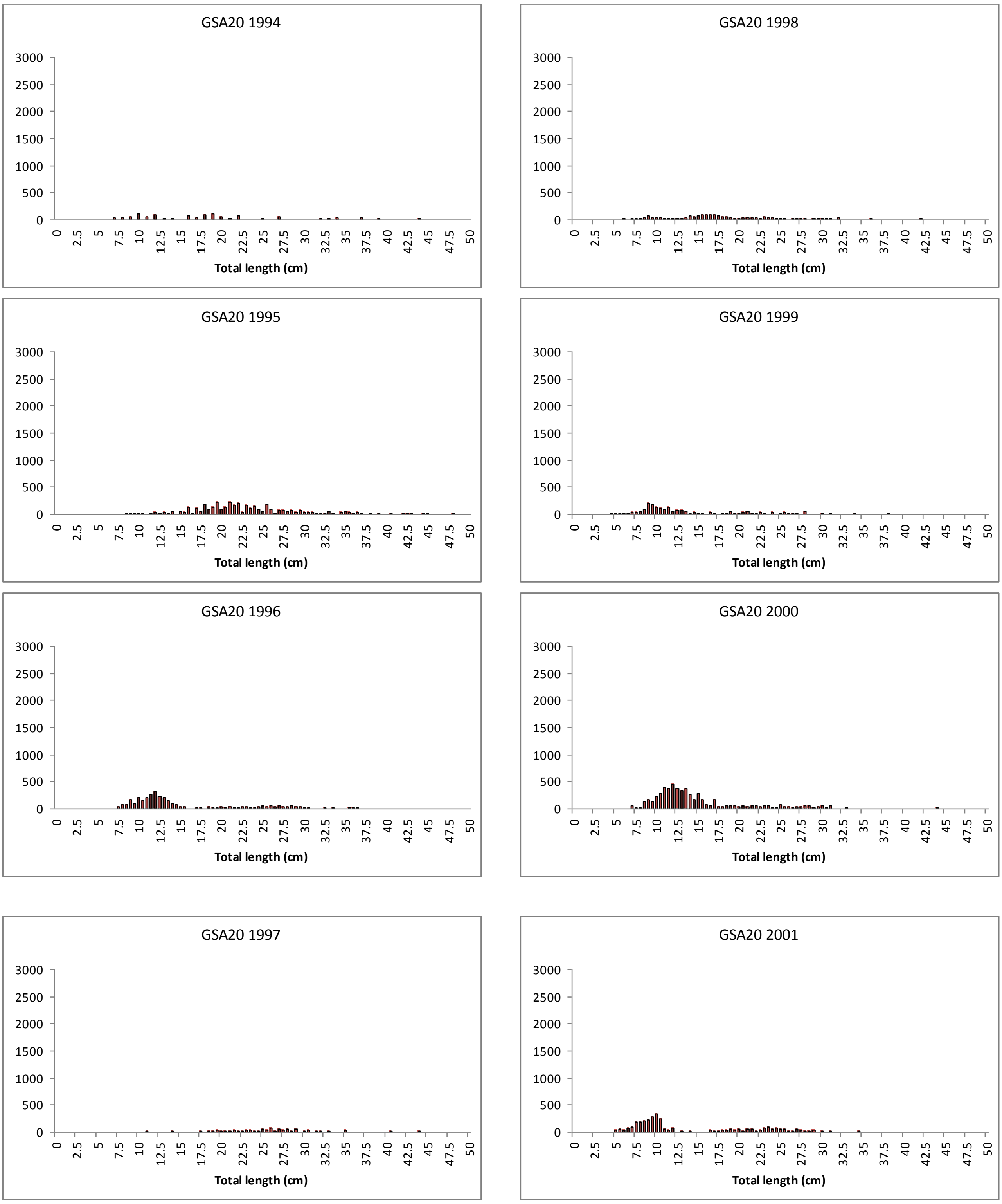
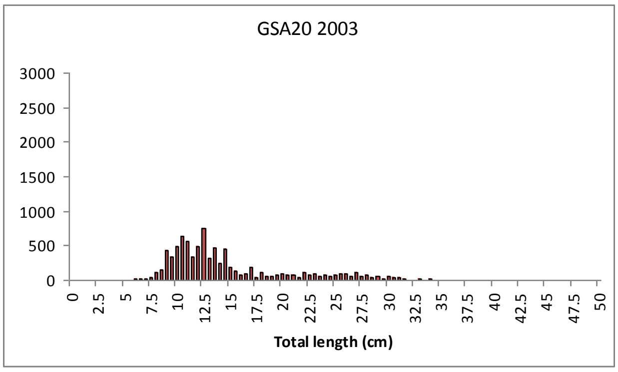
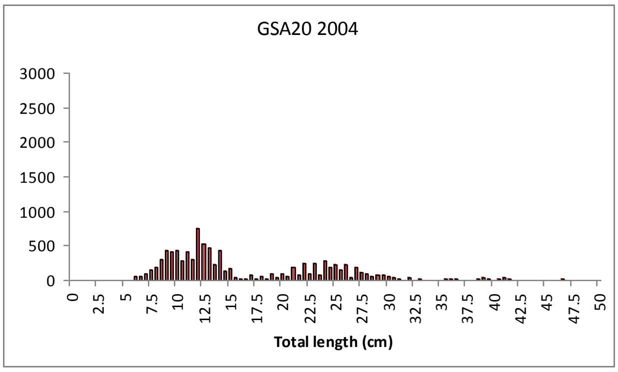
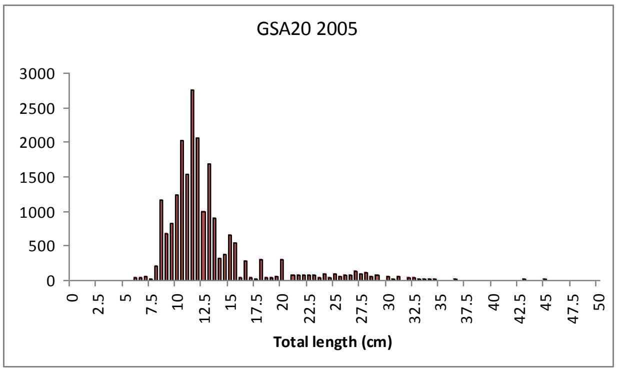
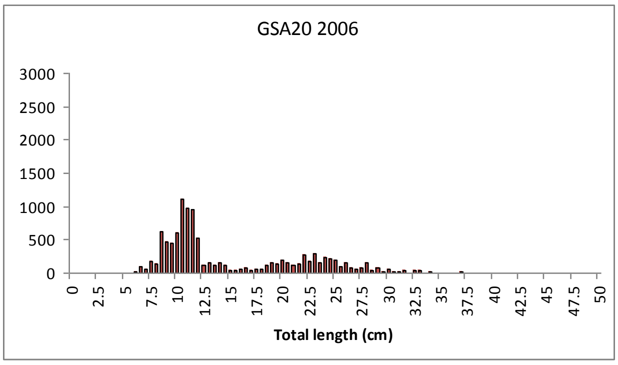



**Fig. 1.13.3.3. Stratified abundance indices by size of Hake in GSA 20, 1994-2001.**


GSA20 2003
3000
2500
2000
1500
1000
500
0
0 2.5 5 7.5 10 12.5 15 17.5 20 22.5 25 27.5 30 32.5 35 37.5 40 42.5 45 47.5 50
Total length (cm)


GSA20 2004
3000
2500
2000
1500
1000
500
0
0 2.5 5 7.5 10 12.5 15 17.5 20 22.5 25 27.5 30 32.5 35 37.5 40 42.5 45 47.5 50
Total length (cm)


GSA20 2005
3000
2500
2000
1500
1000
500
0
0 2.5 5 7.5 10 12.5 15 17.5 20 22.5 25 27.5 30 32.5 35 37.5 40 42.5 45 47.5 50
Total length (cm)


GSA20 2006
3000
2500
2000
1500
1000
500
0
0 2.5 5 7.5 10 12.5 15 17.5 20 22.5 25 27.5 30 32.5 35 37.5 40 42.5 45 47.5 50
Total length (cm)

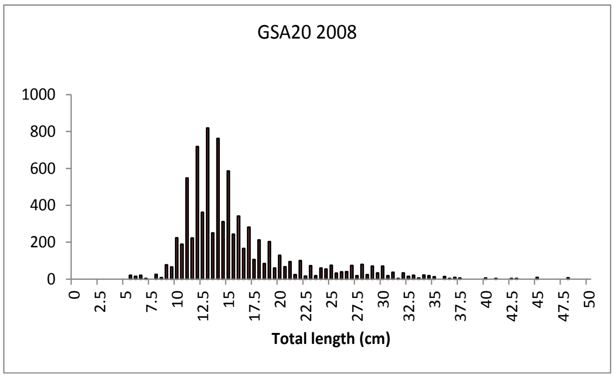

GSA20 2008
1000
800
600
400
200
0
0 2.5 5 7.5 10 12.5 15 17.5 20 22.5 25 27.5 30 32.5 35 37.5 40 42.5 45 47.5 50
Total length (cm)

**Fig. 1.13.3.4. Stratified abundance indices by size of hake in GSA 20, 1994-2001.**

***Trends in growth***

No analyses were conducted.

***Trends in maturity***

No analyses were conducted.

1.13.4 *Assessment of historic stock parameters*

1.13.4.1 Method 1: Length Cohort Analysis-VIT

***Justification***

A pseudocohort analysis was performed for 2005, using VIT software (Lleonart and Salat, 1992) (see "Data quality" at the end of this chapter).

***Input parameters***

The analysis was carried out using numbers at age obtained from length frequencies distribution (Fig. 1.13.4.2) separated by gear (GTR: trammel nets, LLS: long-lines, OTB: bottom trawling) with VIT software. The set of parameters used for the assessment of hake in GSA20 was the same as those used in SURBA and derived from Mellon- Duval et al. (2010).

Table 1.13.4.1 shows the input parameters, numbers at length in 2005, used in the LCA performed for hake in GSA20 (see also Fig. 1.13.4.1).

**Table 1.13.4.1. Input data for LCA of hake in GSA 20.**

| TL (cm) | GTR | LLS | OTB |
|---|---|---|---|
| 8 | | | |
| 10 | | | 576482,3 |
| 12 | | | 1797963 |
| 14 | | | 1244502 |
| 16 | | | 896714,5 |
| 18 | 367147,6 | | 1263233 |
| 20 | 3120755 | | 713790,7 |
| 22 | 2934267 | | 375046,7 |
| 24 | 3961176 | | 286939 |
| 26 | 5007409 | | 368159,4 |

| | | | |
|---|---|---|---|
| 28 | 2334163 | | 279186,5 |
| 30 | 2147676 | 2080,649 | 169760,1 |
| 32 | 722639,8 | | 117926,1 |
| 34 | 541979,8 | 2080,649 | 44921,07 |
| 36 | | 8322,597 | 9589,905 |
| 38 | | 8322,597 | 4794,952 |
| 40 | | 10403,25 | |
| 42 | | 18725,84 | |
| 44 | | 18725,84 | |
| 46 | | 29129,09 | |
| 48 | | 18725,84 | |
| 50 | | 20806,49 | |
| 52 | | 27048,44 | |
| 54 | | 18725,84 | |
| 56 | | 12483,9 | |
| 58 | | 8322,597 | |
| 60 | | 2080,649 | |
| 62 | | 6241,948 | |
| 64 | | | |
| 66 | | 4161,299 | |

***Results***

The main results of the LCA 2005 are shown in Table 1.13.4.2 and Fig. 1.13.4.1. The mean length of the catch was 21.0 cm TL with a critical length of 17.9 cm. The estimated recruitment and SSB were 248 million and 1577 t respectively. Fishing mortality peaked on the age classes 1 and 2 decreasing on older ages. This fishing pattern is different from that observed in other GSAs, where trawl landings, dominated by juveniles of the 0 group, are the main component of the total landings.

The estimated mean $F_{0\text{-}5}$ and $F_{1\text{-}4}$ were respectively 0.61 and 0.89. GTR were responsible of 68% of the estimated F.

**Table 1.13.4.2. Summary results of stock parameters for hake in GSA 20 derived from VIT model (Gear1= GTR; Gear2=LLS, Gear3= OTB).**

| --- | Total | Gear 1 | Gear 2 | Gear 3 |
|---|---|---|---|---|
| Catch mean age | 1214 | 1345 | 328 | 0819 |
| Catch mean length | 21.031 | 23276 | 48042 | 14476 |
| Mean $F_{1\text{-}4}$ | 0.617 | 0,42 | 0,117 | 0,079 |
| Total catch | 3143583,46 | 2464832,12 | 227430,96 | 451320,38 |
| Spawning Stock Biomass, SSB (tons) | 1577,44 | | | |
| Number of recruits, R (million | 248,3 | | | |

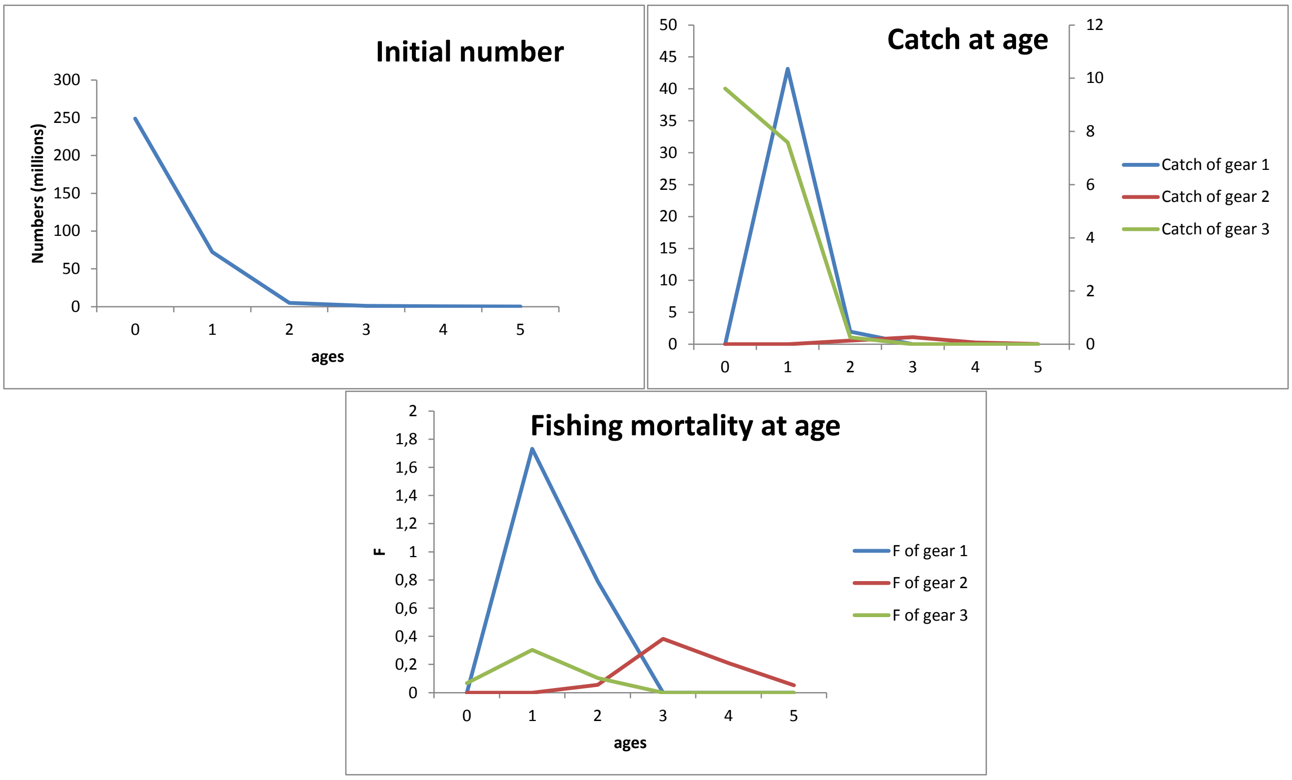



**Fig. 1.13.4.1. LCA outputs: numbers at age, catch at age and fishing mortality at age, by gear, of hake in GSA20 (gear1= GTR; gear2= LLS; gear3= OTB. left axis: GTR; right axis: LLS and OTB.**

### 1.13.4.2 Method 2: Production model-ASPIC

A production model has been employed in order to estimate the fishing mortality and the biomass at sea and the relative reference points in term of $F_{MSY}$ and $B_{MSY}$, using the catch and effort data estimated by Moutopoulos and Stergiou, 2012.

***Input parameters***

A non-equilibrium dynamic biomass model incorporating covariates [ASPIC 5.10.1] (Prager 2005) was applied to catch and effort (hP x Days) data from the GSA 20. Input data consists of 2 sets of time series of total landings (in t) of hake and standardized fishing effort expressed as fishing days * total HP for GSA 20 for GNS+LLS derived from official data (Fig. 1.13.4.1.). However no sensible results could be obtained when the model was run using the 2 time-series simultaneously. Thus, only the fishing gear with the most important contribution in terms of landings, i.e. the GTR+LLS dataset (for the period 1970-2007 the landings for OTB and GTR+LLS ranged from 43.0 t to 930.7 t and from 248.0 to 1902 t, respectively), was considered in the final model. In addition to data on catch and effort, ASPIC requires starting guesses and ranges for the parameters to be estimated by the model: carrying capacity (K), maximum sustainable yield (MSY), the ratio of the biomass at the beginning of the first year to the carrying capacity (B1/K) and catchability (q) (Table 1.13.4.3).

**Table 1.13.4.3. ASPIC input parameters of the FIT mode for GSA 20.**

| B1/K | MSY | Range of MSY | K | Range of K | Fishing fleet | q (mean (CPUE) / 2*max(Y)) |
|---|---|---|---|---|---|---|
| 1.552 | 2.276E+03 | 1.0E+03-4.0E+04 | 1.072E+04 | 5.0E+03-4.0E+04 | Small scale | 6.79E-09 |

After fitting the values for the above parameters, the FIT mode is run. At this point ASPIC computes estimates of parameters, including time trajectories of fishing intensity and stock biomass. The results of the fit were used to compute bias-corrected approximate confidence limits (80% CL) through bootstrap analysis. The model fittings are under the assumption that yield in each year is known more precisely than fishing effort or relative abundance from Medits survey, which has been discarded from the model because did not provide a better fit. In other words, all model fittings were conditioned on yield, rather than on effort or relative abundance (Prager 2005).

If there is normal convergence, the point estimates of the FIT mode were loaded in the BOT mode for bootstrapping. In this mode the programme computes bootstrap confidence intervals on estimated quantities. This approach resamples the residuals from the optimum fit to generate new bootstrap samples of the observed time series. The residuals between the observed and predicted catch rates (CPUE), are used for bootstrap analysis. Bootstrap data sets are constructed by combining predicted CPUE with a randomly chosen residual to compute a pseudo-CPUE value. The model is then refit, using the pseudo-CPUE, which is assumed to relate back to stock biomass via the catchability coefficient (CPUE = qBt). The process is repeated at least 1000 times (bootstrap trials) for each different fit. At each trial the objective function used is the sum of squared errors (Haddon 2001, Prager 2005).

***Results***

Initial runs in the ASPIC FIT mode and the observed CPUE and predicted CPUE indexes are shown in Figure 1.13.4.2. A clear decreasing trend in CPUEs is observed for all the runs. However, the model is not able to properly fit over the observed values and the $R^2$ value is low and around 0.21.

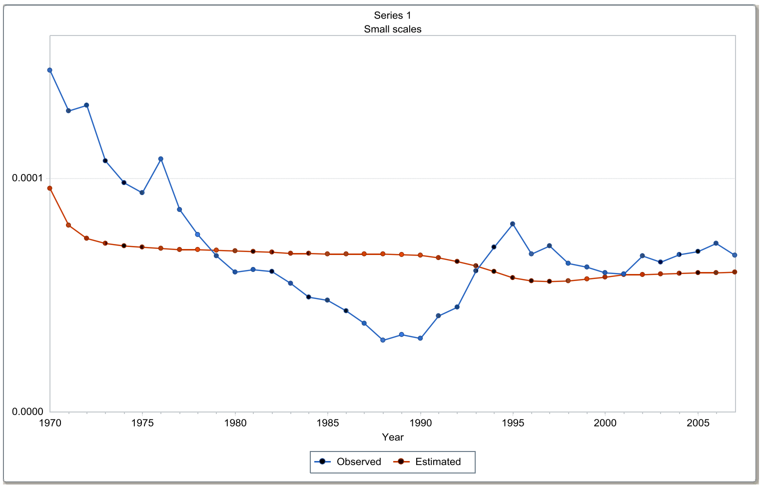



**Fig.1.13.4.2. Observed and predicted values of CPUE of hake in GSA 20 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1970-2008.**

In the logistic model the estimated biomass decreased respectively from 14000 to 9000 t, whereas the fishing mortality F increased from 0.02 to 0.14 (Figure 1.13.4.3). The biomass was estimated to be lowest since 1970, while the F reached highest values from 1995 to 2007. The estimated surplus production shows a high level for the last decade (Figure 1.13.4.4).

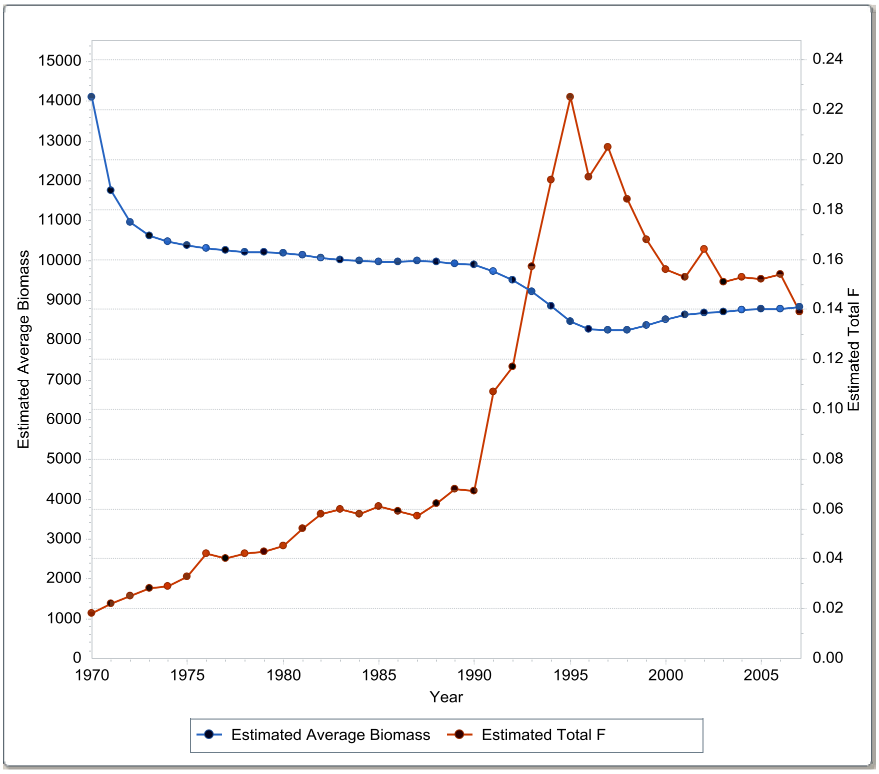



**Fig.1.13.4.3. Estimated average biomass and fishing mortality of hake in GSA 20 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1970-2007.**

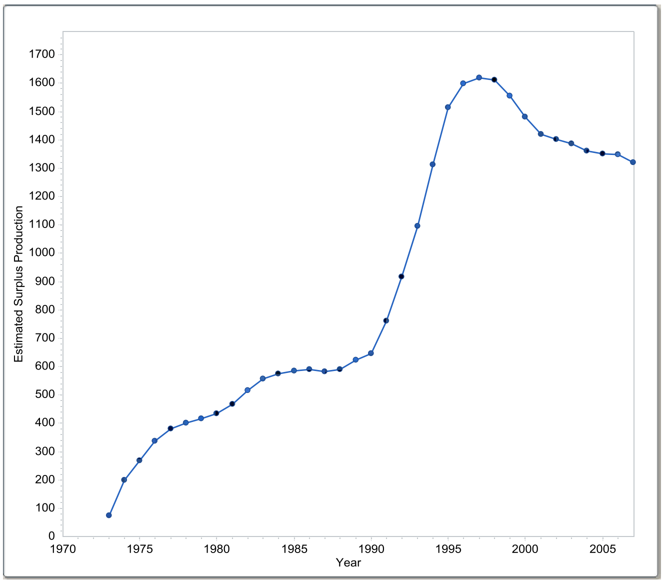



**Fig.1.13.4.4. Estimated surplus production of hake in GSA 20 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1970-2008.**

The goodness of fit of each model is presented in Table 1.13.4.4. The logistic model presented a general good fit also in terms of contrast and nearness.

**Table 1.13.4.4. Goodness of fit results for the logistic model in ASPIC.**

| Loss component number and title | Weighted SSE | N | Weighted MSE | Current weight | In. var. weight | R-squared CPUE |
|---|---|---|---|---|---|---|
| Loss(-1) SSE in yield | 0.00E+00 | | | | | |
| Loss(0) Penalty for B1 > K | 1.931E-01 | 1 | | 1.00E+00 | | |
| Loss(1) Small scales | 4.594E+00 | 38 | 1.276E-01 | 1.00E+00 | 1.00E+00 | 0.210 |
| TOTAL OBJECTIVE FUNCTION, MSE, RMSE: | 4.787E+00 | | 1.368E-01 | 3.698E-01 | | |
| Estimated contrast index (ideal = 1.0): | 0.7861 | | C* = (Bmax-Bmin)/K | | | |
| Estimated nearness index (ideal = 1.0): | 0.7342 | | N* = 1 - \|min(B-Bmsy)\|/K | | | |

The estimates of MSY, $B_{MSY}$, $F_{MSY}$, $f_{MSY}$ for GTR are shown in Table 1.13.4.5 and the estimates of MSY and $F_{MSY}$ ranges after bootstrapping using approximate 80% upper and lower confidence limits are shown in Table 1.13.4.6.

**Table 1.13.4.5. Estimated parameters of Hake in GSA 20.**

| Model | MSY (tons) | $B_{MSY}$ (tons) | $F_{MSY}$ | B(2008)/Bmsy | F(2007)/Fmsy | $f_{MSY}$ Small scale |
|---|---|---|---|---|---|---|
| **Logistic** | 2.276E+03 | 5.359E+03 | 4.247E-01 | 1.656E+00 | 3.265E-01 | 6.255E+07 |

**Table 1.13.4.6. Estimates of MSY and $F_{MSY}$ from bootstrapped analysis in ASPIC with confidence limits.**

| Model | MSY | | | $F_{MSY}$ | | |
|---|---|---|---|---|---|---|
| | 80% lower | | 80% higher | 80% lower | | 80% higher |
| **Logistic** | 1.804E+03 | 2.276E+03 | 3.814E+03 | 3.117E-01 | 4.247E-01 | 7.698E-01 |

The relative biomass ($B/B_{MSY}$) and fishing mortality ($F/F_{MSY}$) are showed in Figure 1.13.4.5 for the logistic model.

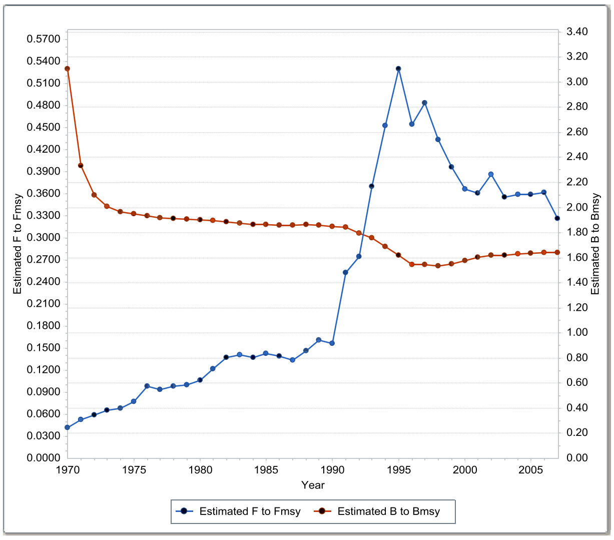



**Fig.1.13.4.5. Historic trend in estimated fishing mortality as $F/F_{MSY}$ ratio and biomass as $B/B_{MSY}$ ratio from Logistic model.**

The general fit of the model is rather poor ($r^2$ is estimated to be around 0.20) and the model is not able to reproduce the observed trends. Thus the EWG consider that the model output is not reliable for the assessment of hake in GSA 20.

#### 1.13.4.3 Method 3: SURBA (Survey Based Assessment)

***Justification***

The relatively long time series of data available from the MEDITS surveys provided the most useful data set to analyse the trend of hake stock in GSAs 20. The MEDITS indices of abundance (n/hour) for hake in GSA 20, covering the period 1994-2008 were analysed using SURBA (SURvey-Based stock Assessment approach, Needle, 2003). The annual standardized size distributions (1 cm length class) from MEDITS were converted in age distributions using the statistical slicing method approach developed during STECF EWG 11-14 (Scott et al., 2011). In each year a single age distribution was obtained for the two sexes combined.

The slicing was carried out using both the classical knife edge approach and by fitting different distributions (normal, lognormal, gamma) over the LFD data (Fig. 1.13.4.6). Result of the statistical slicing are showed in Figure 1.13.4.7.

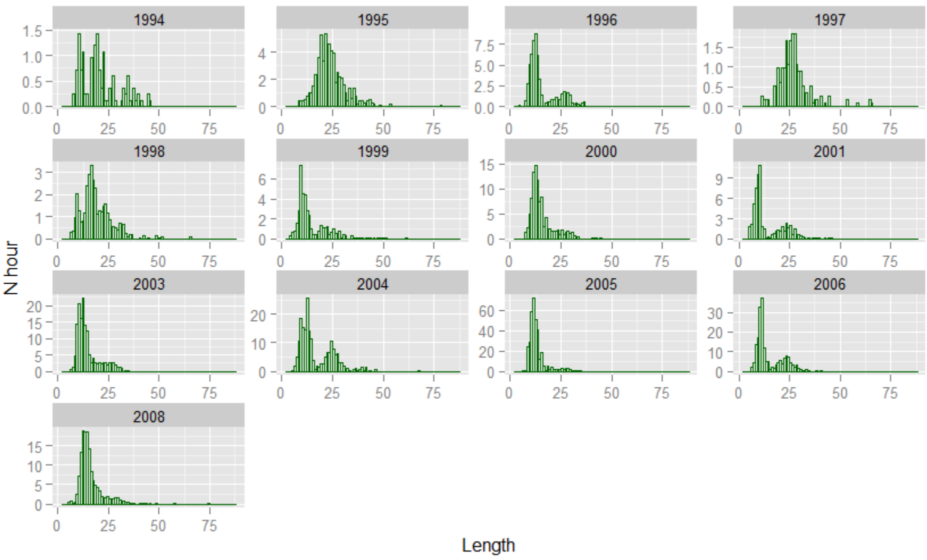
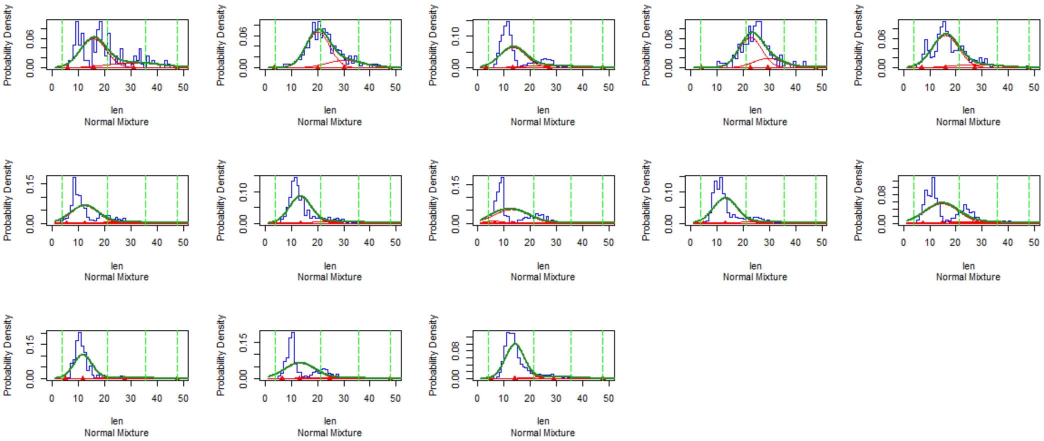
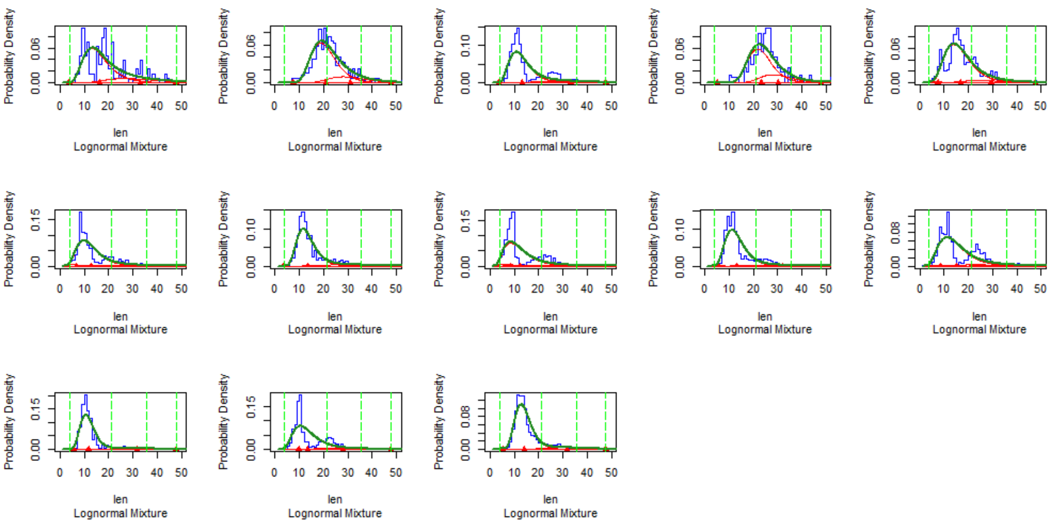



**Fig. 1.13.4.6. MEDITS length frequency distributions of hake in the GSA 20.**

Normal




Lognormal




Gamma distribution

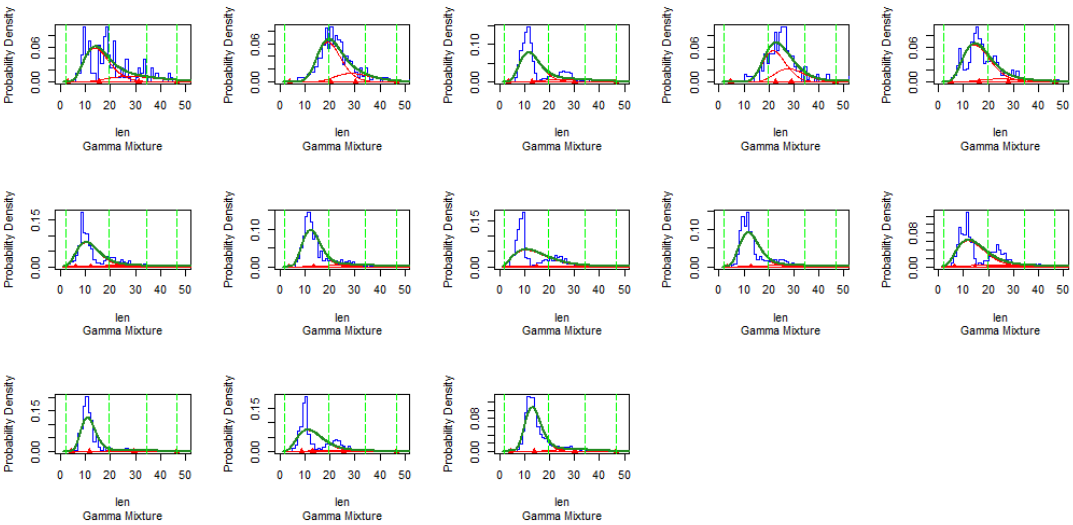



**Fig. 1.13.4.7. Result of fitting normal, lognormal and gamma distribution to 1994-2008 LFD data for hake in GSA 20. The red triangles on the x-axis indicates the position of mean of each distribution. The green vertical lines indicate where the von Bertalananffy growth curve places each age group. For**

**the last three ages this coincides with the mean of the distribution because that is how we set our constraints.**

The value of chi-squared ($\chi^2$) and the degrees of freedom (df) were calculated for each distribution to compare the fits by calculating the reduced $\chi^2_{red}$, where $\chi^2_{red} = \chi^2$ /df (see Table 1.13.4.5). The adopted role of thumb is that the larger the $\chi^2_{red}$, the worse the fit. Since the better fit does not imply that the resulting estimates of mean-length-at –age are biological consistent, the final choice of the distribution depends also by the final judgement of the scientist. To this aim we have considered the reliability of the length-at age estimated by the three distributions and the consistence of the resulting cohorts.

**Table 1.13.4.5. Reduced chi-squared ($\chi^2_{red} = \chi^2$ /df )values from fitting with the three distributions.**

| | normal | lnorm | gamma |
|---|---|---|---|
| 1994 | 0.15 | 0.15 | 0.15 |
| 1995 | 0.11 | 0.16 | 0.14 |
| 1996 | 0.66 | 0.42 | 0.49 |
| 1997 | 0.11 | 0.13 | 0.12 |
| 1998 | 0.12 | 0.11 | 0.10 |
| 1999 | 0.36 | 0.20 | 0.24 |
| 2000 | 0.55 | 0.27 | 0.36 |
| 2001 | 0.93 | 0.61 | 0.73 |
| 2003 | 1.07 | 0.55 | 0.76 |
| 2004 | 2.03 | 1.38 | 1.52 |
| 2005 | 2.19 | 1.17 | 1.41 |
| 2006 | 2.50 | 1.60 | 1.84 |
| 2008 | 0.41 | 0.22 | 0.27 |

After checking the estimated mean length at age and the fitting of the SURBA model over the different numbers-at-age matrices obtained from the statistical slicing, we decided to adopt the data matrix calculated with the knife edge slicing (Fig. 1.13.4.7). It returned the more consistent pattern, capturing the recruitment cohorts resulting from the long spawning season of the species into the first age group. The statistical slicing in most of the annual distributions attributed a high proportion of age 0 specimens into the age 1 group. In terms of mortality estimates it produced very high Z, between age 1 and 2 and a rather unstable temporal pattern.

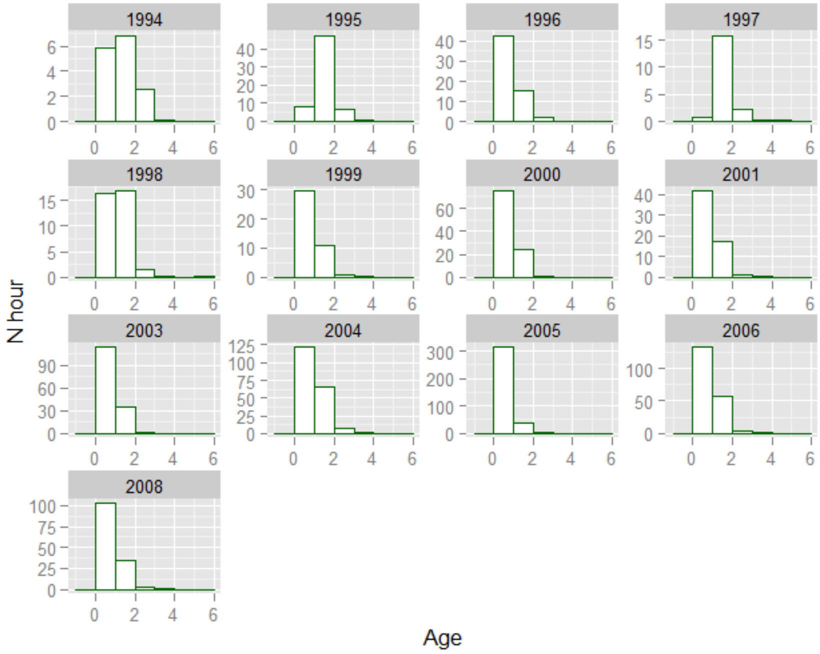


**Fig. 1.13.4.7. Numbers at age distributions of hake for MEDITS 1994-2008 in GSA 20 obtained by knife edge slicing.**

***Input parameters***

Table 1.13.4.6 shows the input parameters using to run SURBA. The age group 0 was removed from the dataset because they are not caught during MEDITS. The survey is generally carried out just before the recruitment period and therefore the survey catch does not include the 0 group.

Single survey exploratory SURBA 2.2 model runs were carried out fitting constant catchability (1.0 for all ages) catchability at age.

The model settings are given below:
Year range: 1994-2008, 2002 and 2007 lacking
Age range: 1-5+
Catchability: age 0 (1.0), age 1(1.0), age 2 (0.8), age 3 (0.7), age 4 (0.6), age 5 (0.6)
Age weighting : 0.5 for age 0, 1.0 at ages 1-2 , and 0.8 for age 3- 5+
Smoothing Index Rho: 2.0
Cohort weighting: not applied

**Table 1.13.4.6. Input parameters of SURBA.**

**Growth parameters**

| Sex | L∞ | k | t0 | a | b |
|---|---|---|---|---|---|
| F+M | 110 | 0.278 | 0 | 0.0000035 | 3.024 |

**Proportion of mature**

| Age | | | | | |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5+ |
| 0 | 0.3 | 0.75 | 1 | 1 | 1 |

**Natural mortality**

| | | | | | |
|---|---|---|---|---|---|
| Age | | | | | |
| 0 | 1 | 2 | 3 | 4 | 5+ |
| 1.17 | 0.67 | 0.56 | 0.52 | 0.50 | 0.3 |

***Results***

Comparative scatterplots at age indicated a lack of consistency of the MEDITS data, between age 2 against age3 and age 3 vs age 4 plus the year after (Fig. 1.13.4.8).

The trends in $F_{1\text{-}4}$, SSB and recruitment at age 0 from SURBA run, and the model residuals are given in Figures 1.13.4.9-10. The retrospectives for the MEDITS survey data are given in Figure 1.13.4.11.

The estimates can be considered reliable since 1998 when the sampling effort increased from 18-28 to 32 stations sampled. In the period 1998-2008 the model estimates large fluctuations in the temporal effect with an increase since 2000. The age effect declines from ages 1 to age-5+. The cohort effect shows an increase through time.

The estimated relative SSB increased continuously until 2008, whereas the recruitment increased until 2005 and decreased since then.

The total mortality (Z) was estimated to be stable between 1.3-2.3 in 1997-2007, while showing an increasing pattern in the period 2003-07. $F_{1\text{-}4}$ (bootstrapped estimates) were unreliable in 1994-97 and 2003 (5% percentile of bootstrapped runs below 0). $F_{1\text{-}4}$ ranged between 0.42 and 0.81 in 1998-2003, showing an increasing pattern in 2003-2007 from 0.42 (2003) to 1.42 (2007). The residuals at age do not show any major pattern. The retrospective showed large uncertainty in the estimation of the age effect.

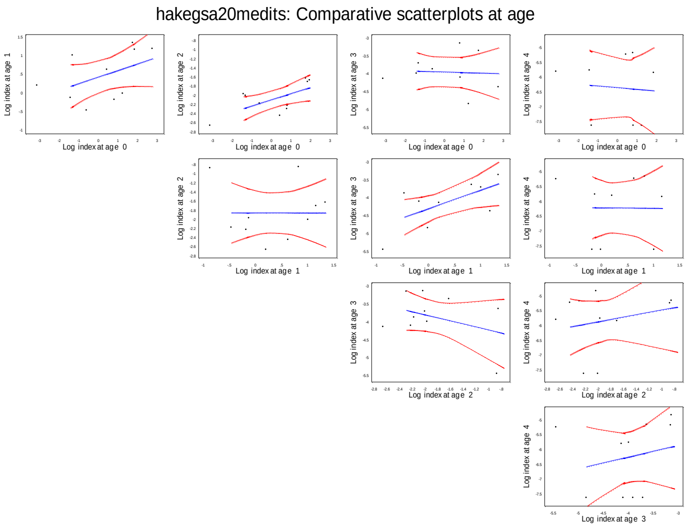
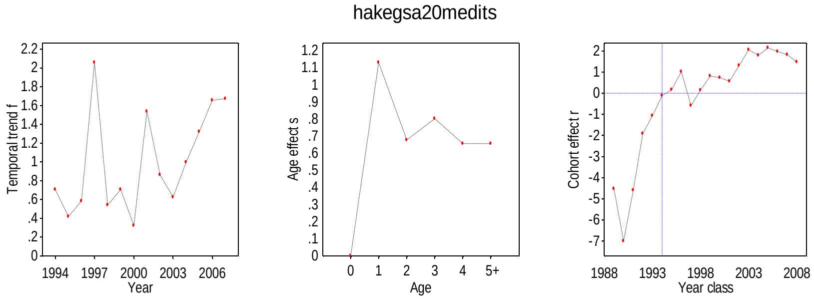
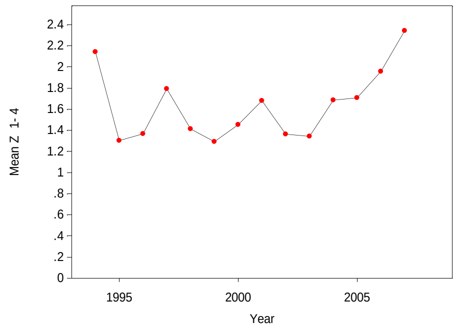



**Fig. 1.13.4.8. Hake in GSA 20: Output from SURBA plots for MEDITS survey (ages 1-5), showing age scatter plots.**

A)




B)




C)

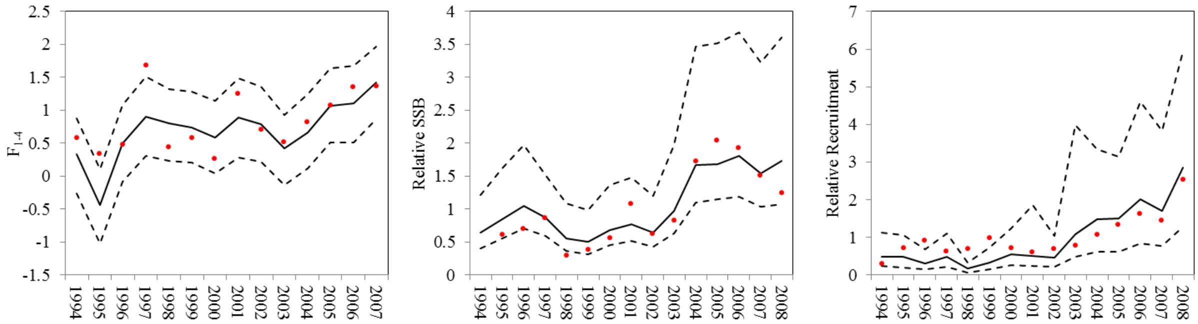
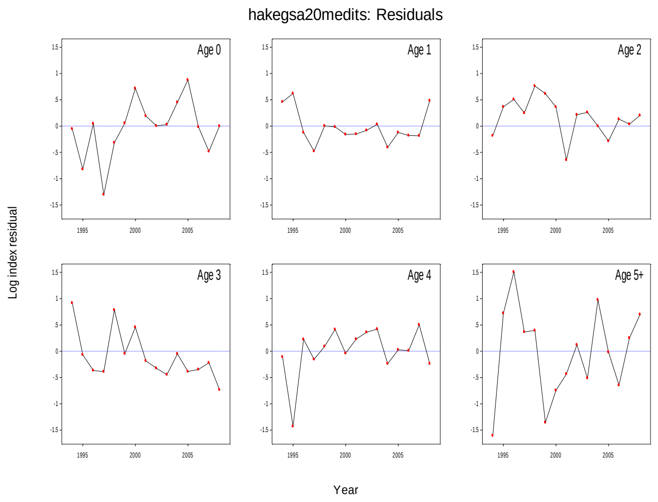



**Fig. 1.13.4.9. SURBA estimates for hake in GSA 20. A) model parameters. B) total mortality ($Z_{1-4}$) c) bootstrapped (lines) and fitted (points) estimates of $F_{1-4}$, SSB, recruitment, solid and dotted lines are respectively 50% and 5- 95% of bootstrapped estimates**

A)




B)

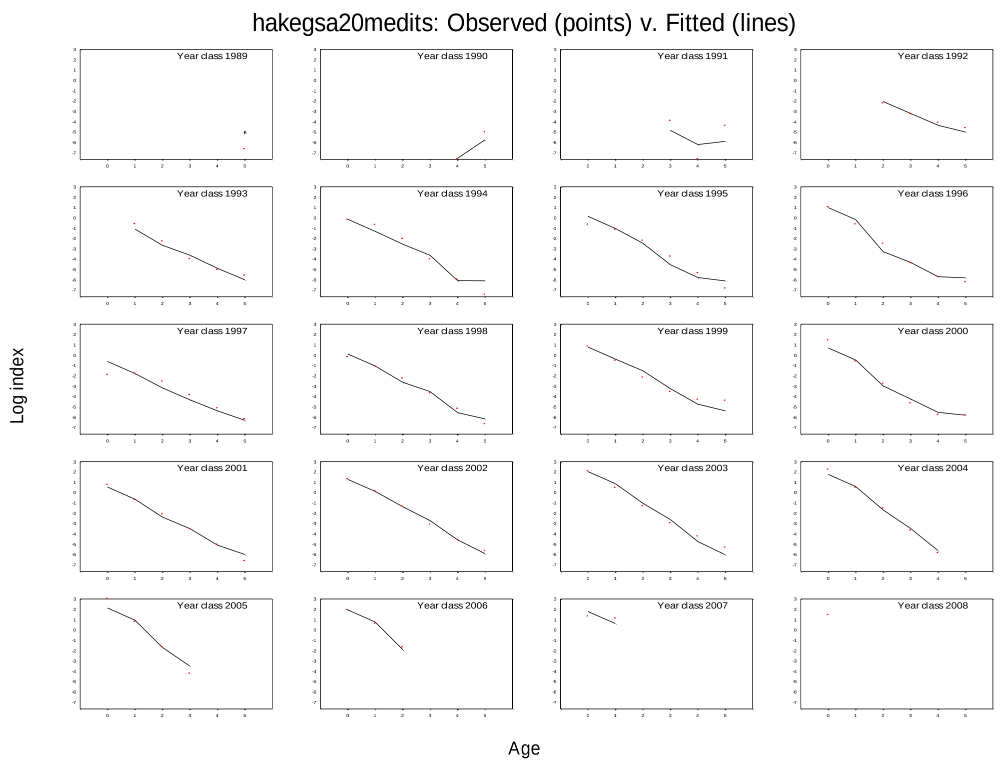



**Fig. 1.13.4.10. SURBA model diagnostic for hake in GSA 20. A) Temporal trend in residuals by age B) Observed (points) and fitted (lines) year classes**

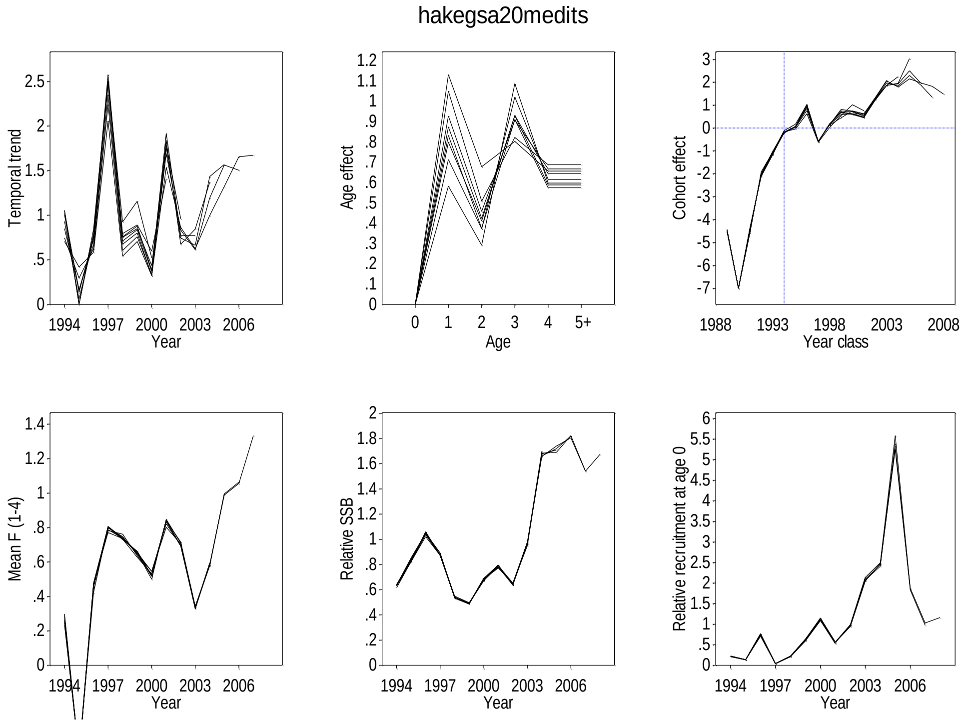



**Fig. 1.13.4.11. Hake in GSA 20. SURBA model: retrospective analysis.**

1.13.5 *Short term prediction for 2008 and 2009*

Justification

No forecast analyses were conducted.

Input parameters

No forecast analyses were conducted.

Results

No forecast analyses were conducted.

1.13.6 *Medium term prediction* -

Justification

No forecast analyses were conducted.

Input parameters

No forecast analyses were conducted.

Results

No forecast analyses were conducted.

## 1.13.7 *Long term prediction*

Justification

An YPR (yield per recruit) analysis was carried using the results of the VIT analysis for 2005.

***Input parameters***

The same used for the pseudocohort analyses with VIT.

Results

Table 1.13.7.1 and Figure 1.13.7.1 show the results of the YPR on 2005 data. The estimated $F_{01}$ factor was 0.44 and the resulting $F_{01}$ for $F_{1-4}$ was therefore 0.39. $F_{01}$ estimated for the whole stock is 0.27.

**Tab. 1.13.7.1. Results of the YPR analysis (Gear1= GTR; Gear2=LLS, Gear3= OTB).**

| ___ | Factor | Y/R | B/R | SSB | Y/R Gear 1 | Y/R Gear 2 | Y/R Gear 3 |
|---|---|---|---|---|---|---|---|
| F(0) | 0 | 0 | 0,151 | 0,132 | 0 | 0 | 0 |
| Max Gear2 | 0,31 | 0,012 | 0,062 | 0,05 | 0,008 | 0,003 | 0,001 |
| F(0.1) | 0,44 | 0,014 | 0,043 | 0,032 | 0,01 | 0,003 | 0,002 |
| Max(:) | 0,58 | 0,014 | 0,031 | 0,022 | 0,01 | 0,002 | 0,002 |
| Max Gear1 | 0,72 | 0,014 | 0,022 | 0,014 | 0,01 | 0,002 | 0,002 |
| Max Gear3 | 0,88 | 0,013 | 0,016 | 0,009 | 0,01 | 0,001 | 0,002 |
| phi=1 | 1,01 | 0,013 | 0,012 | 0,006 | 0,01 | 0,001 | 0,002 |
| phi=2 | 2 | 0,009 | 0,005 | 0,001 | 0,008 | 0 | 0,002 |

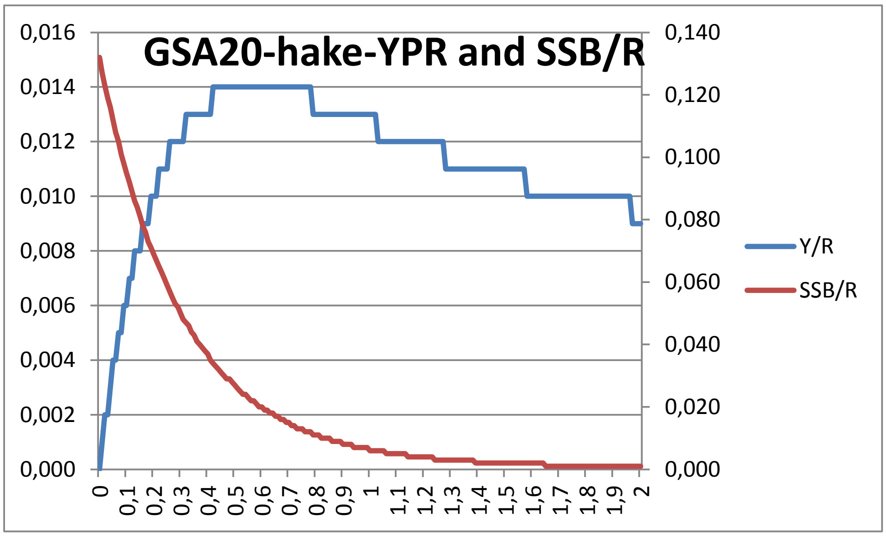



**Fig. 1.13.7.1. YPR outputs. YPR(left axis) and SSB/R (right axis), in grams, for hake in GSA20 in 2005. Note that x- axis indicates factor (not F value).**

### 1.13.8 *Data quality*

Data used in the LCA were taken from the access database "SGMED 2009 fisheries data 20100118GRConly". A number of gaps and inconsistencies were found in the DCR Fisheries data, which determined the years that could be used as input for LCA. The main problem was that landings data by gear taken from the database or calculated from the size distributions by gear were rather different, due to the lack of data on sizes (Fig. 1.13.8.1). For this reason, the annual size distributions were very different (Fig. 1.13.8.2). Taking into account that the fishing gear with highest landings is GRT, 2004 and 2005 were chosen as input for LCA. 2005 OTB data were made available during the assessment by participant experts. In 2006 and 2008 the data for trammel nets (GRT), total landing and LFD, were lacking and this explain the large differences observed in the total landing and size structure of the landings between 2004-05 and 2006-08.

No data on discards available and no data for 2007.

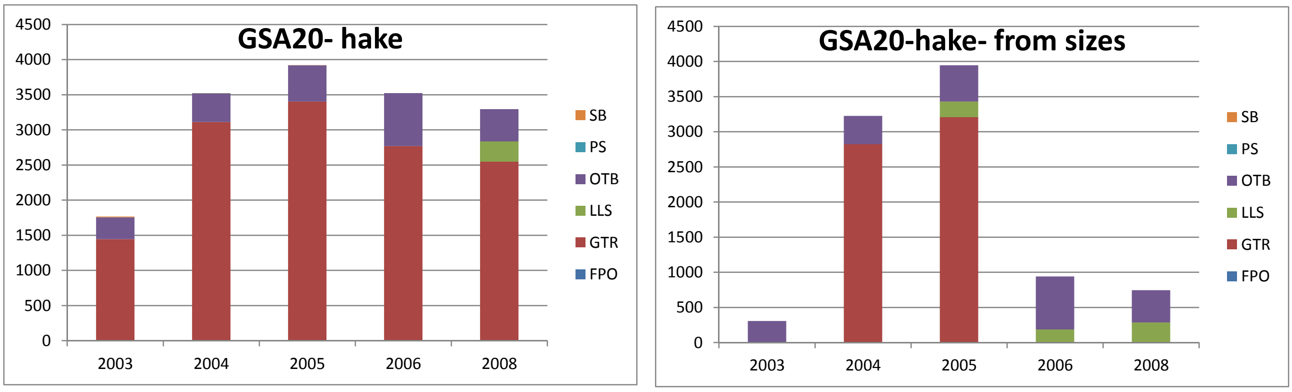



**Fig. 1.13.8.1. Hake annual landings (t) in GSA20, as taken from the access database (left) and calculated from the annual size distributions by gear (rigth).**

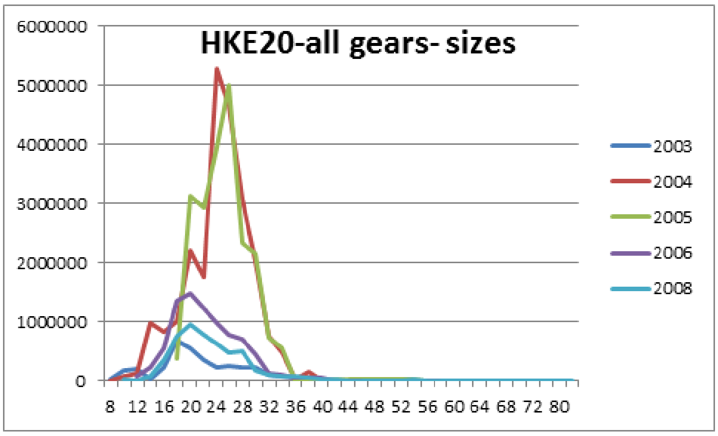



**Fig. 1.13.8.3. Hake annual size distributions (numbers) in GSA20 (data source: access database).**

### 1.13.9 *Scientific advice*

#### 1.13.9.1 Short term considerations

***State of the stock size***

Stock assessment has been computed by Length Cohort Analysis (VIT software) using as input DCR data of the annual length distributions of 2005. The production model (ASPIC) did not return a reliable pattern in the stock trend, as well as reliable estimates. The general fit of the model is rather poor ($r^2$ is estimated to be around 0.20). Thus the EWG consider that the model output is not reliable for the assessment of hake in GSA 20.

SURBA analysis of the MEDITS data (1994-08) showed an increasing trend in SSB since 2003. Since no biomass reference levels for the stock of hake in GSA 20 were proposed, the STECF ad-hoc WG-for the assessment of Greek stocks cannot evaluate the stock status in relation to these.

***State of recruitment***

SURBA analysis of the MEDITS data (1994-08) showed an increasing trend in recruitment since 2003.

***State of exploitation***

STECF ad-hoc WG on the assessment of Greek stocks proposes $F_{0.1} \leq 0.27$ as proxy of $F_{MSY}$. $F_{1-4}$ estimate derived from the Length Cohort Analyses (LCA) in 2005 ($F_{1-4}$=0.89) was larger than $F_{MSY}$.

The survey data (SURBA analysis) indicated an increasing pattern in $F_{1-4}$ since 2003. SURBA estimates for $F_{1-4}$ were 1.06 in 2005 and 1.42 in 2007. Based on the results of the LCA assessment, STECF ad-hoc WG-reassessment of Greek stocks considers the stock of hake in the GSA 20 exploited unsustainably until 2007.

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## 1.14 **Stock assessment of hake in GSA 22&23**

### 1.14.1 *Stock identification and biological features*

#### 1.14.1.1 Stock Identification

Hake is one of the most important fish stocks in GSAs 22&23 for bottom trawlers, nets (mainly gillnets) and longlines. The stock is distributed in depth between 50-600 m, with a peak in abundance in depths between 200 and 300 m. The stock is exploited by the Greek fishing fleet in the National Greek waters and by the Greek and Turkish fleet in the international waters. Spawning is taking place all year around, with a peak during winter –spring.

#### 1.14.1.2 Growth

Biological sampling was conducted in 16 fishing ports, which are the main landing ports of the GSAs 22&23. Landings from trawlers, nets and hooks were included in biological sampling. Sampling was conducted during different seasons for each species depending on the life cycle of the species, the size of local production, and the temporal or spatial restrictions on the use of fishing gears.

The growth curves for hake and for each sex are given for GSAs 22-23 in Figure 1.14.1.1. The age interpretation was done by otolith reading. Sampling was conducted from 2003 to 2005.

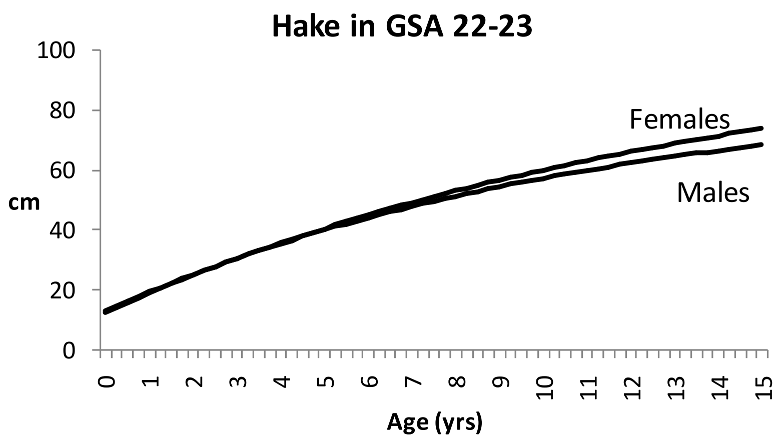



**Fig. 1.14.1.1 Growth curves of male and female hake in GSA 22&23.**

SGMED 08-04 agreed to adopt the fast growth curve (Tab. 1.14.1.1), as calculated in the Gulf of Lions by Mellon Duval et al. (2010), to assess hake in GSA 20.

**Tab. 1.14.1.1. Growth parameters of hake according to the French tagging experiments.**

| **HAKE** | **$L_\infty$ (cm)** | **k** | **$t_0$** |
|---|---|---|---|
| **F+M** | 110 | 0.178 | 0 |

The natural mortality at age vector for hake in GSA 20 , as estimated using these growth parameters with the Prodbiom method (Abella et al., 1997), is showed in Table 1.14.1.2.

**Tab. 1.14.1.2. Natural mortality vector for hake in GSA 20.**

| M at age | | | | | |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5+ |
| 1.17 | 0.67 | 0.56 | 0.52 | 0.50 | 0.3 |

### 1.14.1.3 Maturity

An $L_{50}$ of 36 cm TL (Stergiou et al., 1997) was used to calculate the proportion of mature specimens at age showed in Table 1.14.1.3.

**Table 1.14.1.3. Proportion of mature hake at age in GSA 22&23.**

| Mature at age | | | | | |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5+ |
| 0 | 0.3 | 0.75 | 1 | 1 | 1 |

## 1.14.2 *Fisheries*

General description of fisheries

Hake mainly lives on muddy substrates in depths between 50-600 m. The main landing ports in the GSAs 22-23 are the port of Pireus, Thessaloniki, Kavala, Alexandroupolis, Volos, Chalkida and Chios.
The bottom trawl fishery in Greece is a mixed fishery, operating 24hr per day. Bottom trawl fishing targeting hake, is taking place mainly during the day in muddy bottoms in depths 80-400 m (approximately). Especially for the offshore fisheries in the international waters, the duration of the trip could be up to 3 days. The mesh size of the cod end of bottom trawls is 40 mm. Important by-catch species are shrimps, anglerfish, blue whiting, Norway lobster, megrims, picarel and red mullet.

The gill-nets are setting in the morning and are hauling the next day in depth from 80-300 m. The mesh size used is about 48 to 64 mm. The fishery is carried out mainly during summer when bottom trawl fishery is closed. Long line fishery for hake is taking place in deeper waters down to 500 m mainly during summer. Fishing is taking place during the day. The size of the hook is No 6-8. Gillnet and especially longline fisheries have a relatively greater species and size selectivity. The main by catch species in the gill net fishery is horse mackerel.

Due to the selectivity of each gear the length composition differs significantly. The catch from bottom trawls consists mainly of small individuals (hake with lengths between 6-18 cm are ~75% of the catch). The catch of gillnets comprises mainly of specimens with lengths between 20 and 40 cm, while longliners catch relatively larger fish.

There was a general declining trend in the number of vessels in recent years in all fleet segments. Capacity generally declined, except in trawlers where it increased. The average length slightly increased in all fleet segments, except boat seiners. Average age substantially declined in all fleet segments except boat seiners where average age remained stable and the highest among all fishing fleets.

### *Management regulations applicable in 2007 and 2008*

RD 917/1966 is the principal law regulating the operation of trawlers. Although this law is still in effect, it has been superseded by EC Regulation 1626/1994, and its replacement Regulation 1967/2006. The main restrictions established by Greek and European legislation are:

(1) establishment of a total exclusion zone one mile from the coastline of the mainland and the islands,
(2) a total fishing ban from the 1st of June till the end of September,
(3) establishment of a total exclusion zone which is: either a zone three miles from the coastal line or a zone shallower than 50 m,
(4) minimum cod-end mesh size is 40 mm (EU EC regulation 1967/2006); from 1 July 2008, the net shall be replaced by a square-meshed net of 40 mm at the cod-end or, at the duly justified request of the shipowner, by a diamond meshed net of 50 mm.

Additional restrictions exist for bottom trawling in specific areas: in Pagassitikos, S. Euboikos, Porto Lagos, Thessaloniki, part of the Saronicos Gulf, Oreon Channel trawling is prohibited all year around, while in the Gulf of Kavala, Thermaikos Gulf, Strimonikos Gulf trawling is prohibited from 1st of April till the end of October.

The operation of the bottom set nets is subject to the following main restrictions:
(1) the maximum total length of the trammel length is 6000 m.
(2) the minimum mesh size opening is 16 mm.
(3) monofilament or twine diameter of the net should not exceed 0.5 mm.
(4) the maximum drop of a combined trammel and gill net should not exceed 10 m and the length of combined nets should not exceed 2,500 m.

Catches

### *Landings*

Estimation of landings was based on random sampling in 127 sampling stations (ports) in GSA 22&23. Sampling was conducted on a monthly basis at each sampling station, where a sufficient number of vessels from each fleet segment and gear type were randomly selected and landings by species recorded. Based on these data, average landings per fishing day, by species and for each fishing gear were estimated. Based on total effort estimations, sampled data were raised to the whole fleet to estimate total landings by species, fleet segment, fishing gear, and GSA

The landings of hake in GSA 22&23 are presented in Tab. 1.14.2.1 According to official data, landings increased from 4961 to 9076 t in 2003-2006, decreasing to 7160 t in 2008. Small scale vessels using nets and trawlers landed similar amount of hake in the period considered.

**Table 1.14.2.1. Hake catches per gear and per year in GSA 22&23.**

| Year\Gear | SV | OTB | LLS | GTR | **Total** |
|---|---|---|---|---|---|
| 2003 | 13 | 2443 | 712 | 1793 | **4961** |
| 2004 | 4 | 3572 | 1305 | 2732 | **7613** |
| 2005 | 7 | 3856 | 1460 | 3187 | **8510** |
| 2006 | 15 | 3821 | 1469 | 3771 | **9076** |
| 2008 | 8 | 3793 | 747 | 2612 | **7160** |

Length data for long liners landings were provided for the years 2005, 2006 and 2008. LFD of trammel nets were available for the years 2004 and 2005 whereas LFD for OTB were lacking in 2005 (Fig. 1.14.2.1).

The lengths of long line landings ranged from 23 cm to 69 cm. No undersized species were landed by long liners during these years whereas the proportion of the specimens larger than 29 cm was 97% and 95% in 2005 and 2006, respectively. The lengths of the nets landings ranged from 17 cm to 37 cm. A very small proportion of the landings was consisted of undersized specimens.

An analysis of LFDs data was provided during SGMED 08-04. The modal length of trawl landings was 21 cm in 2004 and 2006 and 25-31 cm in 2005. The proportion of the undersized specimens of hake in bottom trawl landings in GSA 22-23 was much lower than in GSA 20. It was 27%, 12% and 33% in 2004, 2005 and 2006, respectively whereas the proportion of specimens with lengths >29 cm was 15%, 38% and 18%, in 2004, 2005, 2006, respectively.

The lengths of hake in the long line landings in GSA 22-23 ranged from 21 cm to 79 cm. No undersized specimens were caught in the long lines. In 2004, the modal length was at 31 cm.

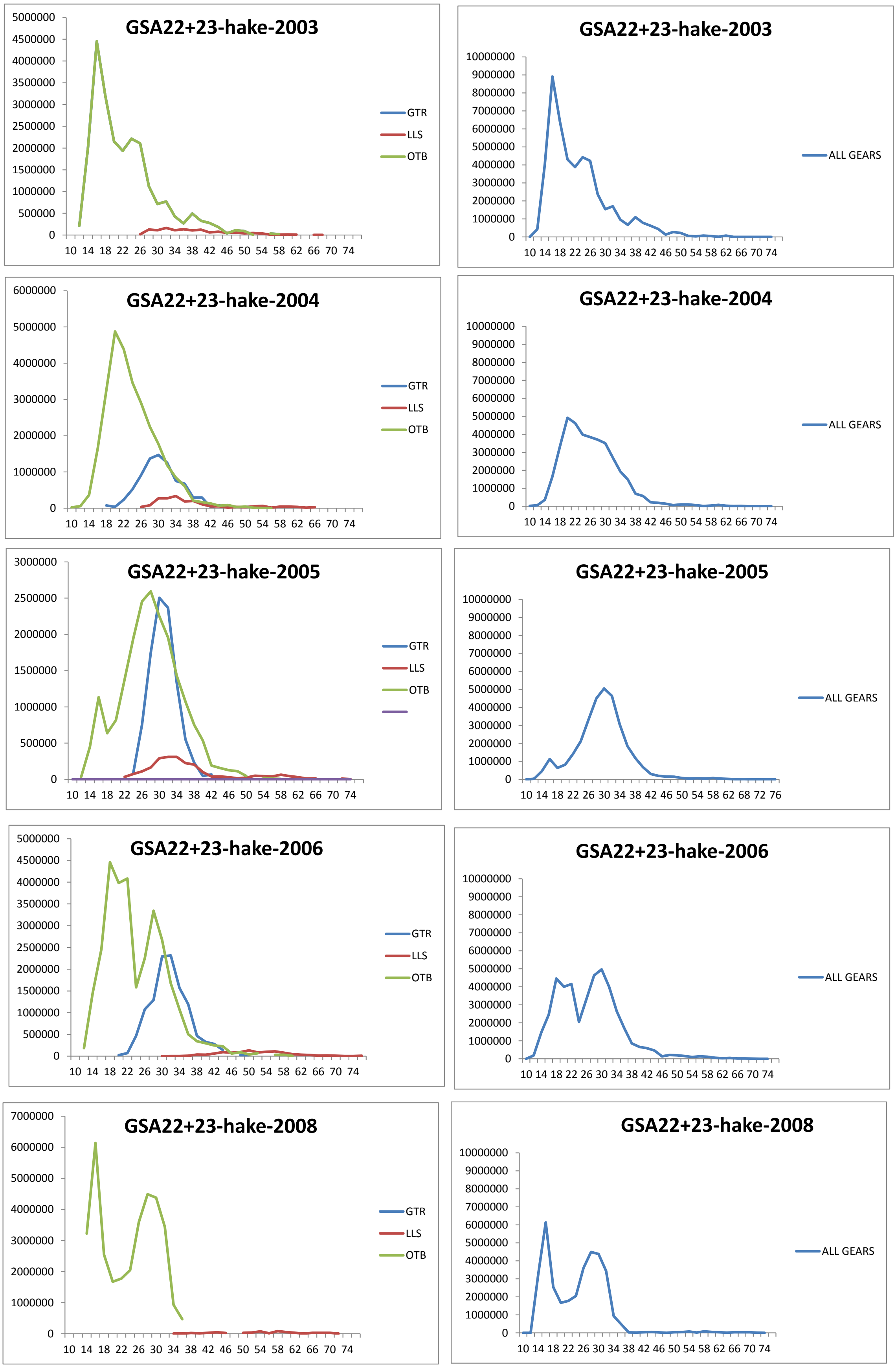



**Fig. 1.14.2.1. Length frequency distributions of hake landings in GSA 20 by gear and year.**

***Discards***

In Greece, the discards and landings of trawlers, purse-seiners, coastal vessels, and drifting longliners were estimated based on on-board sampling. Three times every year, sampling was conducted in the northern and southern parts of GSA 22. Each time, catch, discards, and landings were recorded for each gear type and fleet segment. Based on this sampling, total discards were estimated by species, gear type, and GSA. No length distribution of discards was provided for GSAs 22&23.

Discards of hake in bottom trawl fishery in GSAs 22%23 were estimated 147, 244 and 360 t for the years 2003, 2004 and 2005, respectively (Fig. 1.14.2.2 from SGMED 08-04). Discards for the gillnet fishery were reported in 2004 (9 t) for the segment <12 m and for 2005 (179 t) for both segments. No discards from the longline fishery were reported.

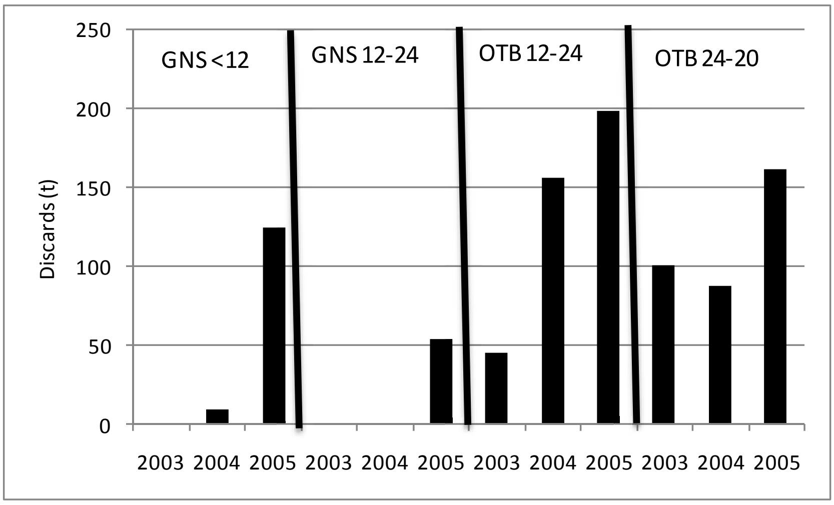



**Fig. 1.14.2.2. Discards of hake in GSA 22&23 per fleet segment.**

***Fishing effort***

A description of the data collection system for fishing effort in GSA 20 was provided in SGMED 08-03.

Estimation of effort was based on interviews conducted with random sampling in 127 sampling stations (ports) in GSA 22-23. Sampling was conducted on a monthly basis at each sampling station, where a sufficient number of vessels from each fleet segment and gear type were randomly selected and effort was recorded. In addition, all fishing vessels present in the sampling stations were categorized as full-time, part-time, occasionally fishing, or inactive, and the proportion of the year they were active was estimated. Based on this information, sampled data were raised to the whole fleet to estimate total effort per fleet segment, fishing gear, and GSA. Should be noted that the estimated effort do not refer to the effective effort targeting to hake but to the entire effort of each fleet segment. This is very important for the long lines and gill nets because the effort targeting hake is much smaller than the effort of the fleets.

The landings of all gears increased in comparison with the landings in 2003 (Fig. 1.14.2.2). In particular, gillnets landings increased from 1,790 to 3,770 t. At the same time effort of gillnets and bottom trawls remained quite constant while effort of longlines decreased. The landings of bottom trawlers in this area are less than 50% of the total.

Estimation of effort was based on interviews conducted with random sampling in 30 sampling stations (ports) in GSA 20. Sampling was conducted on a monthly basis at each sampling station, where a sufficient number of vessels from each fleet segment and gear type were randomly selected and effort was recorded. In addition, all fishing vessels present in the sampling stations were categorized as full-time, part-time, occasionally fishing, or inactive and the proportion of the year when they were active was estimated. Based on this information, sampled data were raised to the whole fleet to estimate total effort per fleet segment, and fishing gear. It should be noted that the estimated effort do not refer to the effective effort targeting to hake but to the entire effort of each fleet segment. This is very important for the long lines and gill nets because the effort targeting hake is much smaller than the effort of the fleets.

The fishing effort of the vessel using trammel nets LOA<12 m showed a significant reduction from 2005 to 2008, bottom trawlers effort was stable, whereas the effort of long liners increased from 2006 to 2008 (Fig. 1.14.2.3).

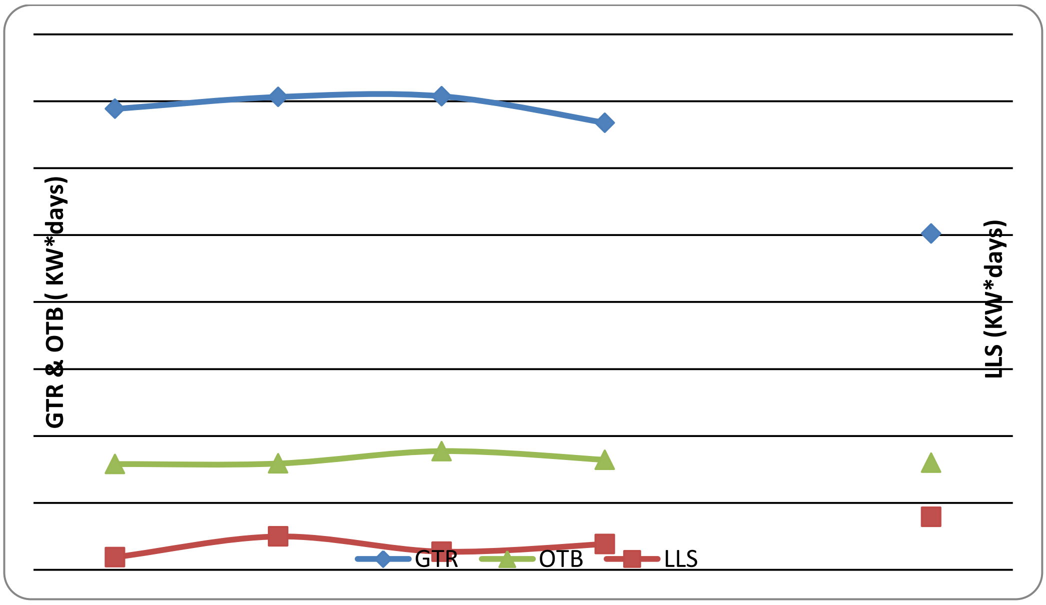



**Fig. 1.14.2.3. Trends in relative (to 2003) fishing effort (kW*days at sea) in GSA 22&23.**

### 1.14.3 *Scientific surveys*

#### 1.14.3.1 Medits

***Methods***

Tables TA, TB, TC were provided according to the MEDITS protocol. The MEDITS survey was carried out in GSAs 22&23 every summer from 1994 to 2006, except in 2002 because of administrative problems. For similar reasons, no MEDITS survey was conducted in Greece in 2007. In GSA 22 & 23, the number of stations was 98 in 1994 and gradually increased to 146 in 1996 and onwards. During the first two years (1994, 1995) the survey was conducted by two scientific teams from two institutes but with the same vessel. From 1996 three scientific teams were involved.

During 1996 and 1997 two commercial vessels were used, and three vessels from 1998. Due to these changes in the survey design, caution is needed when investigating the trends of relevant indicators in the MEDITS time series. More details on methodology and trends on selected indicators may be found in MEDITS (2007).

Based on the DCR data call, abundance and biomass indices were recalculated and presented in section 11 of this report. In GSAs 22 and 23 the following number of hauls were reported per depth stratum ( Tab. 1.14.3.1).

**Tab. 1.14.3.1. Number of hauls per year and depth stratum in GSAs 22 & 23, 1994-2006.**

| Stratum | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2003 | 2004 | 2005 | 2006 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 010-050 | 10 | 10 | 11 | 10 | 13 | 12 | 12 | 13 | 13 | 13 | 14 | 12 | 13 |
| 050-100 | 17 | 21 | 22 | 28 | 23 | 26 | 22 | 25 | 25 | 23 | 24 | 26 | 26 |
| 100-200 | 19 | 25 | 37 | 36 | 37 | 33 | 37 | 35 | 36 | 43 | 41 | 41 | 40 |
| 200-500 | 28 | 35 | 44 | 50 | 51 | 51 | 50 | 48 | 51 | 52 | 52 | 52 | 52 |
| 500-800 | 18 | 12 | 19 | 21 | 22 | 21 | 20 | 17 | 17 | 16 | 17 | 16 | 17 |
| TOTAL | 92 | 103 | 133 | 145 | 146 | 143 | 141 | 138 | 142 | 147 | 148 | 147 | 148 |

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).
The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:
- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).
Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum.

Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

***Geographical distribution patterns***

Figure 1.14.3.1 provides the distribution of sampling hauls of the MEDITS survey in GSA 22&23. No analyses on geographical distribution patterns were conducted.

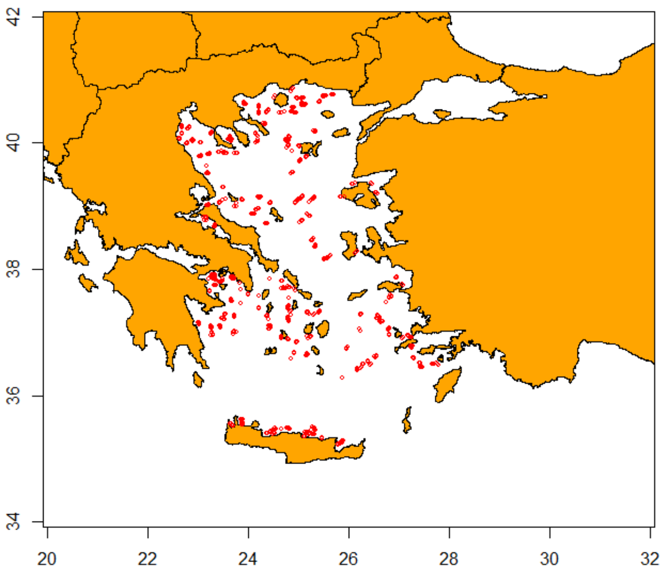



**Fig.1.14.3.1. Distribution of sampling hauls of the MEDITS survey in GSA 22&23.**

***Trends in abundance and biomass***

Fishery independent information regarding the state of the hake in GSAs 22 & 23 was derived from the international survey MEDITS. Figure 1.14.3.2 displays the estimated trend in hake abundance and biomass in GSAs 22 & 23.

The estimated abundance and biomass indices do not reveal any significant trends since 1994. However, the recent abundance and biomass indices in 2006 appear high but are subject to high variation (uncertainty).

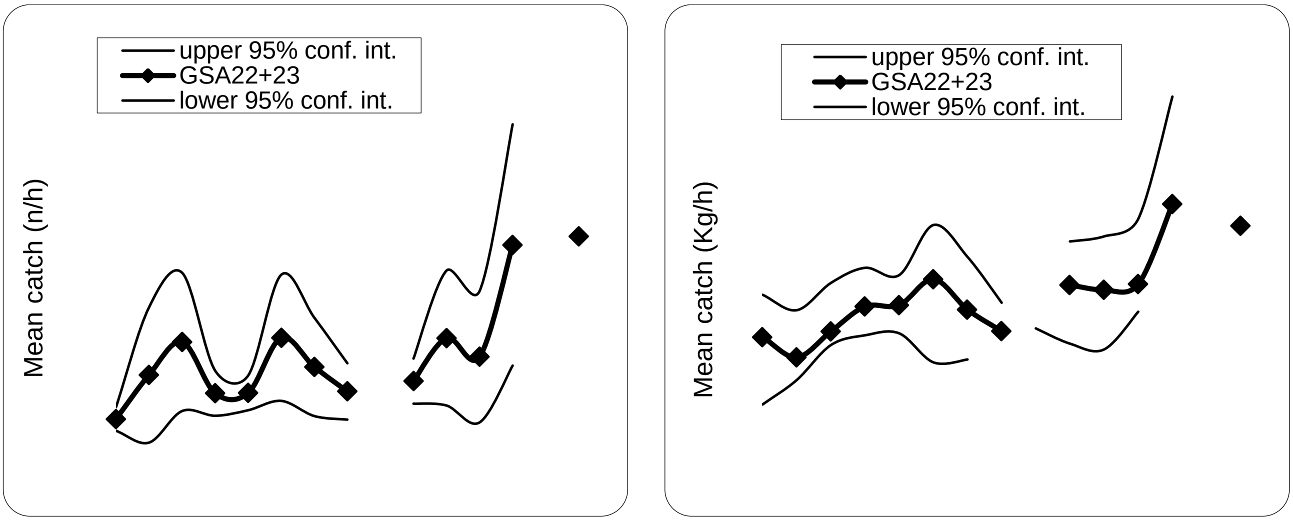



**Fig. 1.14.3.2. Abundance and biomass indices of hake in GSAs 22 & 23.**

***Trends in abundance by length or age***

The following Fig. 1.14.3.3-4 display the stratified abundance indices of GSAs 22&23 combined in 1994-2001 and 2003-2006.

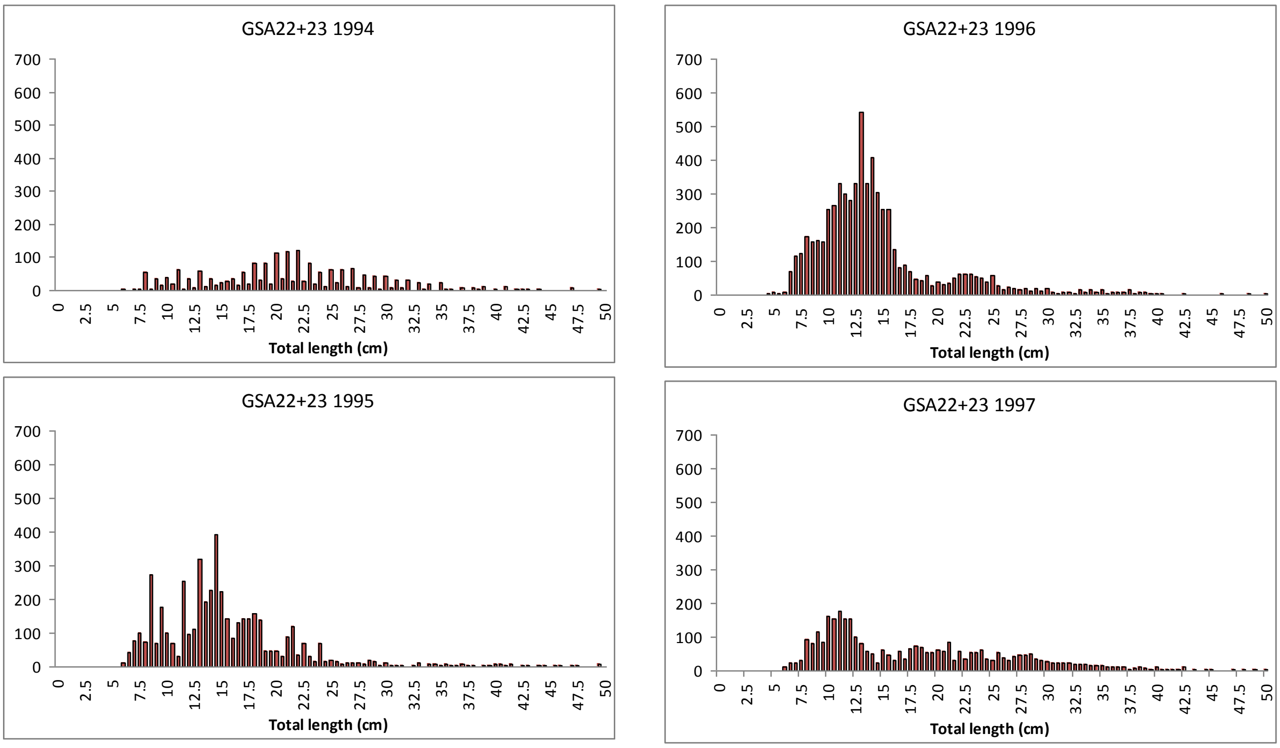
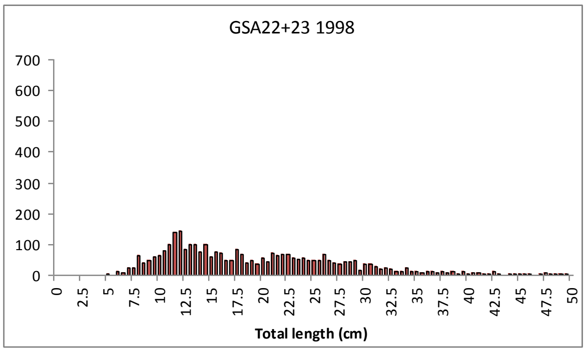
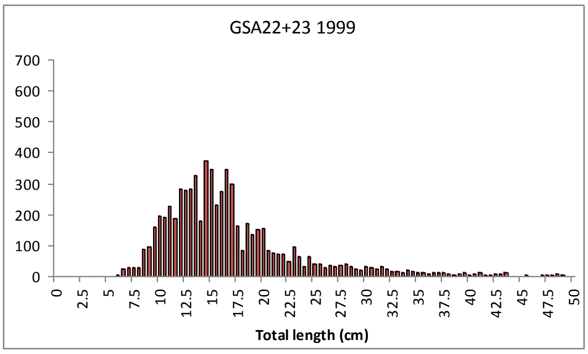
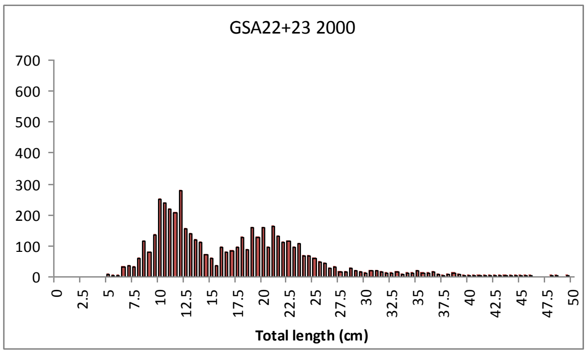
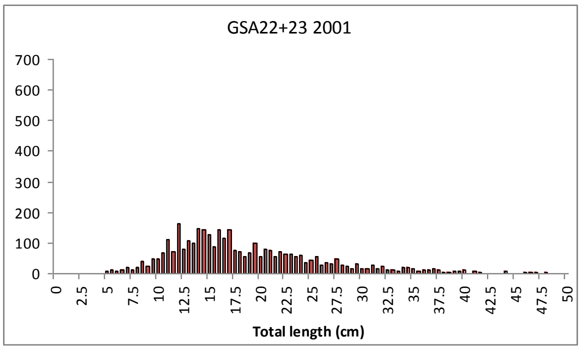


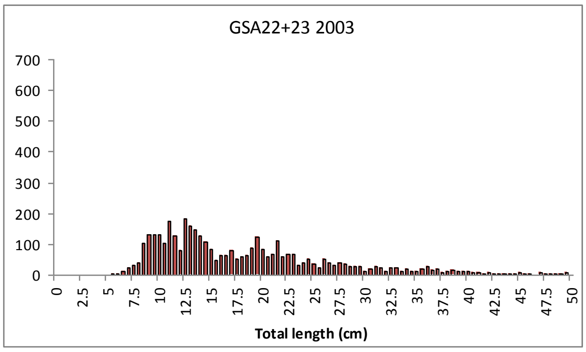

**Fig. 1.14.3.3. Stratified abundance indices by size, 1994-1997.**

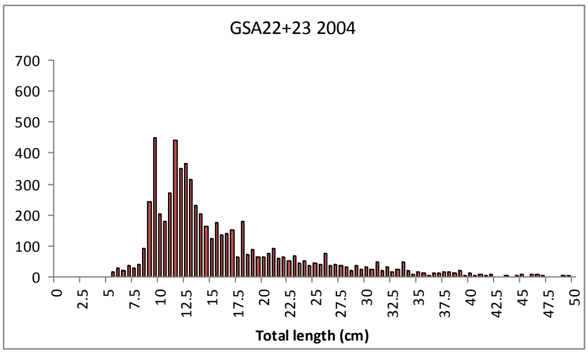

GSA22+23 1998
Total length (cm)

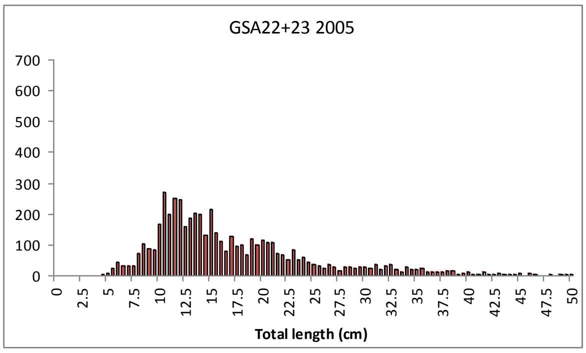

GSA22+23 1999
Total length (cm)

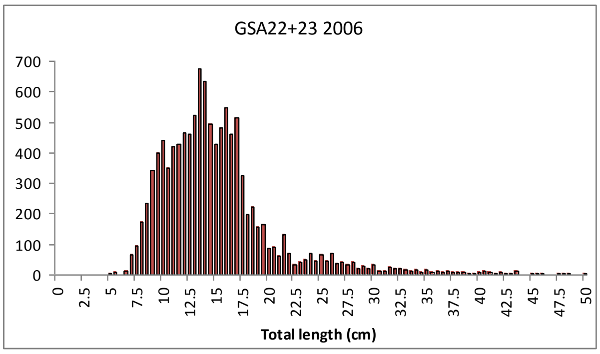

GSA22+23 2000
Total length (cm)


GSA22+23 2001
Total length (cm)


GSA22+23 2003
Total length (cm)


GSA22+23 2004
Total length (cm)


GSA22+23 2005
Total length (cm)


GSA22+23 2006
Total length (cm)

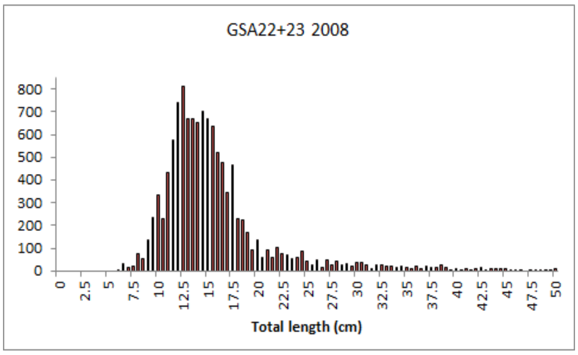

GSA22+23 2008
Total length (cm)

**Fig. 1.14.3.4. Stratified abundance indices by size of hake in GSA 22&23, 2000-2008.**

***Trends in growth***

No analyses were conducted.

***Trends in maturity***

No analyses were conducted.

### 1.14.4 *Assessment of historic stock parameters*

#### 1.14.4.1 Method 1: Length Cohort Analysis-VIT

***Justification***

Three pseudocohort analysis, for 2004, 2005, and 2006, separately, were performed using VIT software (Lleonart and Salat, 1992) (see "data quality" at the end of the analysis).

*Input parameters*

Analyses were performed using the number at age matrix obtained from length frequencies distribution (Tab. 1.14.4.1 and Fig. 1.14.4.1) separated by gear (GTR: trammel nets, LLS: longlines, OTB: bottom trawling) with VIT software. The set of parameters used for the assessment of hake in GSA 22&23 was the same as those used in SURBA and derived from Mellon- Duval et al. (2010).

**Table 1.14.4.1. Hake in GSA 22&23. Input data (n-at-length) used to perform the pseudocohort analysis with VIT by year and gear (GTR: trammel nets; LLS: longlines; OTB: bottom trawling).**

| | 2004 | 2004 | 2004 | 2005 | 2005 | 2005 | 2006 | 2006 | 2006 |
|---|---|---|---|---|---|---|---|---|---|
| | GTR | LLS | OTB | GTR | LLS | OTB | GTR | LLS | OTB |
| 10 | | | 23670,5464 | | | | | | |
| 12 | | | 55304,7617 | | | 36697,5347 | | | 184979,919 |
| 14 | | | 365000,76 | | | 449910,19 | | | 1452035,78 |
| 16 | | | 1658295,42 | | | 1133927,82 | | | 2459955,65 |
| 18 | 76365,1428 | | 3251875,09 | | | 637288,245 | | | 4456546,74 |
| 20 | 38182,5714 | | 4878834,18 | | | 816772,744 | 23408,6008 | | 3980553,03 |
| 22 | 236117,51 | 9093,40464 | 4383321,5 | | 35048,4319 | 1378681,9 | 70225,8025 | | 4084591,87 |
| 24 | 520950,715 | | 3462823,87 | 91882,3458 | 75103,7826 | 1945397,55 | 468172,017 | | 1582186,19 |
| 26 | 916820,593 | 36373,6186 | 2897400,66 | 758029,353 | 110152,214 | 2453985,71 | 1076795,64 | | 2253518,66 |
| 28 | 1371500,41 | 81840,6418 | 2245194,29 | 1745764,57 | 165228,322 | 2591864,47 | 1287473,05 | | 3344810,35 |
| 30 | 1469370,68 | 272802,139 | 1769449,22 | 2503793,92 | 290401,293 | 2250357,43 | 2294042,88 | 1917,20592 | 2673631,12 |
| 32 | 1254758,29 | 272802,139 | 1184833,32 | 2365970,4 | 310428,968 | 1956438,39 | 2317451,48 | 3834,41184 | 1670916,84 |
| 34 | 753118,305 | 336455,972 | 845433,85 | 1332294,01 | 310428,968 | 1430467,23 | 1568376,26 | 3834,41184 | 1076016,83 |
| 36 | 676753,162 | 190961,497 | 613613,885 | 551294,075 | 225311,348 | 1074143,78 | 1193838,64 | 9586,0296 | 503288,189 |
| 38 | 294927,448 | 200054,902 | 210999,41 | 229705,865 | 205283,672 | 753867,01 | 468172,017 | 38344,1184 | 345877,548 |
| 40 | 294927,448 | 109120,856 | 167791,927 | 45941,1729 | 100138,377 | 534926 | 327720,412 | 34509,7066 | 298303,272 |
| 42 | 38182,5714 | 54560,4279 | 131227,174 | 68911,7594 | 40055,3507 | 189810,948 | 280903,21 | 59433,3835 | 248148,543 |
| 44 | 76365,1428 | 54560,4279 | 67092,0201 | | 40055,3507 | 157079,248 | 140451,605 | 93943,0901 | 227285,695 |
| 46 | 38182,5714 | 18186,8093 | 90469,7492 | | 30041,513 | 126872,418 | | 82439,8546 | 59731,4897 |
| 48 | | 36373,6186 | 31228,0085 | 22970,5865 | 15020,7565 | 112180,118 | 23408,6008 | 93943,0901 | 92501,0699 |
| 50 | 38182,5714 | 27280,2139 | 43306,3406 | | 25034,5942 | 47285,0903 | 23408,6008 | 134204,414 | 39468,4039 |
| 52 | 38182,5714 | 54560,4279 | 12578,2792 | | 50069,1884 | | | 86274,2664 | 66619,984 |
| 54 | | 63653,8325 | 4834,91942 | | 45062,2695 | 20694,0985 | | 101611,914 | |
| 56 | | 18186,8093 | 2132,50919 | | 40055,3507 | 10467,8319 | | 109280,737 | 32413,0506 |
| 58 | | 45467,0232 | | | 65089,9449 | 5548,01569 | | 82439,8546 | 34483,5089 |
| 60 | | 45467,0232 | 33900,8867 | | 45062,2695 | | | 47930,148 | 7946,26211 |
| 62 | | 36373,6186 | | | 30041,513 | | | 32592,5007 | |
| 64 | | 18186,8093 | | | 10013,8377 | | | 28758,0888 | 19345,3378 |
| 66 | | 27280,2139 | | | 15020,7565 | | | 15337,6474 | |
| 68 | | | | | | | | 17254,8533 | |
| 70 | | | | | | | | 9586,0296 | |
| 72 | | | | | 10013,8377 | | | 3834,41184 | |
| 74 | | 9093,40464 | | | 5006,91884 | | | 3834,41184 | |
| 76 | | | | | | | | 11503,2355 | |

Results

The pseudocohort analyses returned a similar exploitation pattern in the three years considered (2004-2006), with a similar estimation of $F_{cur}$ and $F_{01}$. Fishing mortality was highest for age class 2 (Fig. 1.14.4.2).

**2004**

The results of the pseudocohort analysis for 2004 are shown in Tables 1.14.4.2-6. The mean length of the catch was 26.0 cm TL with a critical length of 32.9 cm. The estimated recruitment and SSB were 375 million and the 5720 t respectively. Fishing mortality peaked on the age classes 1 and 2 decreasing progressively for older ages. The estimated mean $F_{0\text{-}6}$ and $F_{1\text{-}4}$ were respectively 0.47 and 0.75.

**Table 1.14.4.2. Hake in GSA 22&23, year 2004. Summary results of stock parameters derived from VIT model (Gear1= GTR; Gear2=LLS Gear3= OTB).**

| --- | Total | Gear 1 | Gear 2 | Gear 3 |
|---|---|---|---|---|
| Catch mean age | 1,551 | 1,742 | 2,446 | 1,411 |
| Catch mean length | 26,021 | 28,899 | 37,74 | 24,067 |
| Mean F | 0,467 | 0,119 | 0,145 | 0,203 |
| Global F | 0,247 | 0,057 | 0,015 | 0,175 |
| Total catch | 6659451,11 | 1906040,41 | 1199246,99 | 3554163,71 |
| Catch/D% | 53,94 | 15,44 | 9,71 | 28,79 |
| Catch/B% | 71,58 | 20,49 | 12,89 | 38,2 |
| Current Stock Mean Age | 0,717 | | | |
| Current Stock Critical Age | 2 | | | |
| Virgin Stock Critical Age | 0 | | | |
| Current Stock Mean Lengt | 12,457 | | | |
| Current Stock Critical Leng | 32,948 | | | |
| Virgin Stock Critical Lengtl | 0 | | | |
| Number of recruits, R | 375057059 | | | |
| Mean Biomass, Bmean | 9303594,35 | | | |
| Spawning Stock Biomass, S | 5720322,33 | | | |
| Biomass Balance, D | 12346106,3 | | | |
| Natural death/D | 46,06 | | | |
| Bmax/Bmean | 33,03 | | | |
| Turnover, D/Bmean | 132,7 | | | |

**Table 1.14.2.3. Hake in GSA 22&23, year 2004. Catch at age calculated by slicing method with VIT software model (Gear1= GTR; Gear2=LLS Gear3= OTB).**

| Catch in Numbers | | | | |
|---|---|---|---|---|
| Class | Total catch | Catch of gea | Catch of gea | Catch of gear |
| 0 | 3675118,15 | 0 | 0 | 3675118,15 |
| 1 | 53978770,3 | 10673911,8 | 1158889,27 | 42145969,3 |
| 2 | 12765739,1 | 5671222,74 | 2355105,63 | 4739410,75 |
| 3 | 1096248,49 | 272123,44 | 467603,53 | 356521,52 |
| 4 | 398985,11 | 0 | 334422,24 | 64562,87 |
| 5 | 83047,54 | 0 | 83047,54 | 0 |
| 6 | 19905,31 | 0 | 19905,31 | 0 |
| Total | 72017814,1 | 16617258 | 4418973,53 | 50981582,6 |
| Mean Age | 1,551 | 1,742 | 2,446 | 1,411 |
| Mean Length | 26,021 | 28,899 | 37,74 | 24,067 |

**Table 1.14.4.5. Hake in GSA 22-23, year 2004. LCA output. Stock numbers at age.**

| Class | Initial number |
|---|---|
| 0 | 375057059 |
| 1 | 114473246,7 |
| 2 | 22571343,44 |
| 3 | 3867900,12 |
| 4 | 1479347,42 |
| 5 | 594911,81 |
| 6 | 369819,72 |

**Tab. 1.14.4.6. Hake in GSA 22&23, year 2004. LCA output. Fishing mortality by age and gear model model (Gear1= GTR; Gear2=LLS Gear3= OTB).**

| VPA Results--Mortalities | | | | |
|---|---|---|---|---|
| Class | Total F | F of gear 1 | F of gear 2 | F of gear 3 |
| 0 | 0,017 | 0 | 0 | 0,017 |
| 1 | 0,954 | 0,189 | 0,02 | 0,745 |
| 2 | 1,204 | 0,535 | 0,222 | 0,447 |
| 3 | 0,441 | 0,109 | 0,188 | 0,143 |
| 4 | 0,411 | 0 | 0,344 | 0,066 |
| 5 | 0,175 | 0 | 0,175 | 0 |
| 6 | 0,064 | 0 | 0,064 | 0 |
| Mean Mort. rates | 0,467 | 0,119 | 0,145 | 0,203 |

**2005**

The results of the pseudocohort analysis for 2005 are shown in Tables 1.14.4.7-1.14.1.14. The mean length of the catch was 26.3 cm TL with a critical length of 32.9 cm. The estimated recruitment and SSB were 387 million and the 7818 t respectively. Fishing mortality peaked on the age classes 1 and 2 progressively decreasing for older ages. The estimated mean $F_{0-6}$ and $F_{1-4}$ were respectively 0.44 and 0.67.

**Table1 1.14.4.7. Hake in GSA 22-23, year 2005. Summary results of stock parameters derived from VIT model (Gear1= GTR; Gear2=LLS, Gear3= OTB).**

| --- | Total | Gear 1 | Gear 2 | Gear 3 |
|---|---|---|---|---|
| Catch mean age | 1,583 | 1,842 | 3,623 | 1,4 |
| Catch mean length | 26,307 | 30,331 | 51,471 | 23,755 |
| Mean F | 0,437 | 0,105 | 0,148 | 0,185 |
| Global F | 0,228 | 0,057 | 0,008 | 0,164 |
| Total catch | 7359873 | 2258372 | 1349844 | 3751657 |
| Catch/D% | 51,05 | 15,67 | 9,36 | 26,02 |
| Catch/B% | 61,84 | 18,98 | 11,34 | 31,52 |
| Current Stock Mean Age | 0,766 | | | |
| Current Stock Critical Age | 2 | | | |
| Virgin Stock Critical Age | 0 | | | |
| Current Stock Mean Length | 13,179 | | | |
| Current Stock Critical Length | 32,948 | | | |
| Virgin Stock Critical Length | 0 | | | |
| Number of recruits, R | 3,87E+08 | | | |
| Mean Biomass, Bmean | 11900688 | | | |
| Spawning Stock Biomass, SSB | 7818136 | | | |
| Biomass Balance, D | 14416613 | | | |
| Natural death/D | 48,95 | | | |
| Bmax/Bmean | 31,93 | | | |
| Turnover, D/Bmean | 121,14 | | | |

**Table 1.14.4.8. Hake in GSA 22&23, year 2005. Catch at age calculated by slicing method with VIT software model (Gear1= GTR; Gear2=LLS, Gear3= OTB).**

| Catch in Numbers | | | | |
|---|---|---|---|---|
| Class | Total catch | Catch of gear 1 | Catch of gear 2 | Catch of gear 3 |
| 0 | 6507497,47 | 0 | 0 | 6507497,47 |
| 1 | 47194816,33 | 9543989,82 | 7858,34 | 37642968,17 |
| 2 | 13964299,66 | 7800238,8 | 460258,83 | 5703802,03 |
| 3 | 1731535,44 | 122487,42 | 1100212,31 | 508835,71 |
| 4 | 728200,97 | 0 | 594753,16 | 133447,81 |
| 5 | 143351,73 | 0 | 124992,46 | 18359,28 |
| 6 | 39559,6 | 0 | 39559,6 | 0 |
| Total | 70309261,2 | 17466716,03 | 2327634,7 | 50514910,47 |
| Mean Age | 1,583 | 1,842 | 3,623 | 1,4 |
| Mean Length | 26,307 | 30,331 | 51,471 | 23,755 |

**Table 1.14.4.9. Hake in GSA 22&23, year 2005. LCA output. Stock numbers at age.**

| VPA Results--Numbers | |
|---|---|
| Class | Initial number |
| 0 | 386959788,1 |
| 1 | 116682384,1 |
| 2 | 27909105,89 |
| 3 | 5975566,84 |
| 4 | 2257752,43 |
| 5 | 819834,76 |
| 6 | 485111,92 |

**Table 1.14.4.10. Hake in GSA 22&23, year 2005. LCA output. Fishing mortality by age and gear (Gear1= GTR; Gear2=LLS, Gear3= OTB).**

| VPA Results--Mortalities | | | | |
|---|---|---|---|---|
| Class | Total F | F of gear 1 | F of gear 2 | F of gear 3 |
| 0 | 0,029 | 0 | 0 | 0,029 |
| 1 | 0,761 | 0,154 | 0 | 0,607 |
| 2 | 0,981 | 0,548 | 0,032 | 0,401 |
| 3 | 0,453 | 0,032 | 0,288 | 0,133 |
| 4 | 0,513 | 0 | 0,419 | 0,094 |
| 5 | 0,225 | 0 | 0,196 | 0,029 |
| 6 | 0,099 | 0 | 0,099 | 0 |
| Mean Mort. rates | 0,437 | 0,105 | 0,148 | 0,185 |

**2006**

The results of the pseudocohort analysis for 2006 are showed in Tables 1.14.4.11 - 1.14.4.15. The mean length of the catch was 28.2 cm TL with a critical length of 32.9 cm. The estimated recruitment and SSB were 375 million and the 5645 t respectively. Fishing mortality peaked on the age classes 1 and 2 progressively decreasing for older ages. The estimated mean $F_{0-6}$ and $F_{1-4}$ were respectively 0.52 and 0.83.

**Table 1.14.4.11. Hake in GSA 22&23, year 2006. Summary results of stock parameters derived from VIT model (Gear1= GTR; Gear2=LLS, Gear3= OTB).**

| --- | Total | Gear 1 | Gear 2 | Gear 3 |
|---|---|---|---|---|
| Catch mean age | 1,708 | 1,734 | 2,301 | 1,593 |
| Catch mean length | 28,272 | 28,862 | 35,858 | 26,617 |
| Mean F | 0,518 | 0,14 | 0,185 | 0,193 |
| Global F | 0,218 | 0,084 | 0,019 | 0,116 |
| Total catch | 7564981 | 2778540 | 1361004 | 3425438 |
| Catch/D% | 55,43 | 20,36 | 9,97 | 25,1 |
| Catch/B% | 77,68 | 28,53 | 13,98 | 35,18 |
| Current Stock Mean Age | 0,741 | | | |
| Current Stock Critical Age | 2 | | | |
| Virgin Stock Critical Age | 0 | | | |
| Current Stock Mean Length | 12,895 | | | |
| Current Stock Critical Length | 32,948 | | | |
| Virgin Stock Critical Length | 0 | | | |
| Number of recruits, R | 3,75E+08 | | | |
| Mean Biomass, Bmean | 9738245 | | | |
| Spawning Stock Biomass, SSB | 5645266 | | | |
| Biomass Balance, D | 13648347 | | | |
| Natural death/D | 44,57 | | | |
| Bmax/Bmean | 43,67 | | | |
| Turnover, D/Bmean | 140,15 | | | |

**Table 1.14.4.12. Hake in GSA 22&23, year 2006. Catch at age calculated by slicing method with VIT software model (Gear1= GTR; Gear2=LLS, Gear3= OTB).**

| Catch in Numbers | | | | | |
|---|---|---|---|---|---|
| Class | Total catch | Catch of gear 1 | Catch of g | Catch of gear 3 | |
| 0 | 2739376,86 | 0 | 0 | 2739377 | |
| 1 | 40645958,12 | 16081879,09 | 2022680 | 22541399 | |
| 2 | 20489561,62 | 8977155,21 | 2641227 | 8871179 | |
| 3 | 1088139,55 | 59381,63 | 431401,2 | 597356,7 | |
| 4 | 479246,07 | 0 | 451801,9 | 27444,15 | |
| 5 | 53716,31 | 0 | 53716,31 | 0 | |
| 6 | 34531,63 | 0 | 34531,63 | 0 | |
| Total | 65530530,15 | 25118415,93 | 5635358 | 34776756 | |
| Mean Age | 1,708 | 1,734 | 2,301 | 1,593 | |
| Mean Length | 28,272 | 28,862 | 35,858 | 26,617 | |

**Table 1.14.4.13. Hake in GSA 22&23, year 2006. LCA output. Stock numbers at age.**

| VPA Results--Numbers | |
|---|---|
| Class | Initial number |
| 0 | 374950619,5 |
| 1 | 114931557,6 |
| 2 | 31239735,11 |
| 3 | 3592074,14 |
| 4 | 1322731,63 |
| 5 | 441814,19 |
| 6 | 281415,96 |

**Tab. 1.14.4.15. Hake in GSA 22&23, year 2006. LCA output. Fishing mortality by age and gear (Gear1= GTR; Gear2=LLS, Gear3= OTB).**

| VPA Results--Mortalities | | | | |
|---|---|---|---|---|
| Class | Total F | F of gear 1 | F of gear 2 | F of gear 3 |
| 0 | 0,012 | 0 | 0 | 0,012 |
| 1 | 0,633 | 0,25 | 0,031 | 0,351 |
| 2 | 1,603 | 0,702 | 0,207 | 0,694 |
| 3 | 0,479 | 0,026 | 0,19 | 0,263 |
| 4 | 0,597 | 0 | 0,562 | 0,034 |
| 5 | 0,151 | 0 | 0,151 | 0 |
| 6 | 0,153 | 0 | 0,153 | 0 |
| Mean Mort. rates | 0,518 | 0,14 | 0,185 | 0,193 |

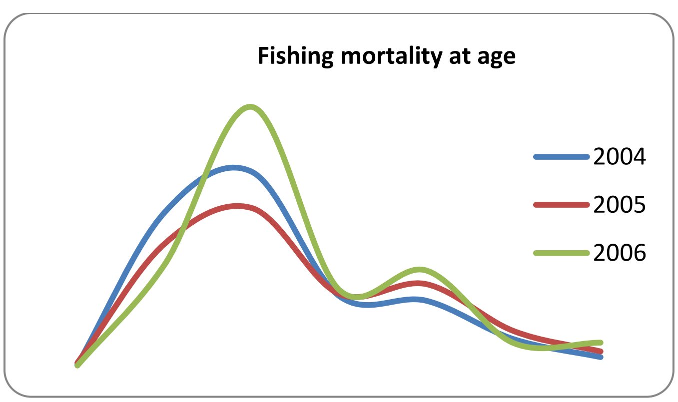



**Fig. 1.14.4.2. Hake in GSA 22&23. Fishing mortality at age (all gears combined).**

### 1.14.4.2 Method 1: Stock Production Model

***Justification***

A production model has been employed in order to estimate the fishing mortality and the biomass at sea and the relative reference points in term of $F_{MSY}$ and $B_{MSY}$, using the catch and effort data estimated by Moutopoulos and Stergiou, 2012.

***Input parameters***

A non-equilibrium dynamic biomass model incorporating covariates [ASPIC 5.10.1] (Prager 2005) was applied to catch and effort (Hp x Days) data from the GSAs 22 and 23. Available data consists of 2 sets of time series of total landings (in t) of hake and standardized fishing effort (expressed as fishing days * total HP) for the main four fleets exploiting the species (Otter trawl, Purse seine, Beach seine and small scale fishery) derived from the reconstructed landing in GSA 22&23 for the period 1967-2007 (see Section I of this report). In addition to data on catch and effort, ASPIC requires starting guesses and ranges for the parameters to be estimated by the model: carrying capacity (K), maximum sustainable yield (MSY), the ratio of the biomass at the beginning of the first year to the carrying capacity (B1/K) and catchability (q) (Table 1.14.4.16).

**Table 1.14.4.16. ASPIC input parameters of the FIT mode for GSA 22 & 23.**

| **B1/K** | **MSY** | **Range of MSY** | **K** | **Range of K** | **Fishing fleet** | **q (mean (CPUE) / 2*max(Y))** |
|---|---|---|---|---|---|---|
| 4.306E-01 | 3.876E+03 | 5.0E+02-1.0E+05 | 4.570E+04 | 2E+00-5.0E+06 | Otter trawl | 4.752E-11 |
| | | | | | Purse seine | 1.435E-10 |
| | | | | | Beach seine | 5.832E-10 |
| | | | | | Small scale | 1.579E-09 |

After fitting the values for the above parameters, the FIT mode is run. At this point ASPIC computes estimates of parameters, including time trajectories of fishing intensity and stock biomass. The model fittings are under the assumption that effort in each year is known more precisely than yield or relative abundance from Medits survey, which has been discarded from the model because did not provide a better fit. In other words, all model fittings were conditioned on effort, rather than on yield or relative abundance (Prager 2005).

***Results***

Initial runs in the ASPIC FIT mode and the observed CPUE and predicted CPUE indexes are shown in Figure 1.14.4.3. A gradually decreasing trend in CPUEs is observed since 1982 having an adequate fit only for small scale fishery, while in the other gears there is not a good fit between observed and estimated data (Table 1.14.4.17). Such evidence is quite understandable for the purse seine and the beach seine, while is quite strange for the otter trawl. This might be attributed to the negative correlations detected between some indices, a fact that major affects the fit of the model. However, all four gears have been considered in the model.


**Fig.1.14.4.3. Observed and predicted values of CPUE of hake in GSA 22&23 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1964-2008.**

Only the logistic model converged, while the fox and the generalized estimated exponenent models did not produce any results. In the logistic model the estimated biomass and fishing mortality fluctuated respectively from 21470 to 28480 t and from 0.0130 to 0.140 (Figure 1.14.4.4). The biomass was estimated to increase at the maximum level 40950 t in 1976 and decrease in the aforementioned value, while the F reached highest values from 1995 to 2007. The estimated surplus production shows its lowest level (< 1450 t) during 1976-1977, whereas it fluctuates above 3500 t during the last decade (Figure 1.14.4.5).

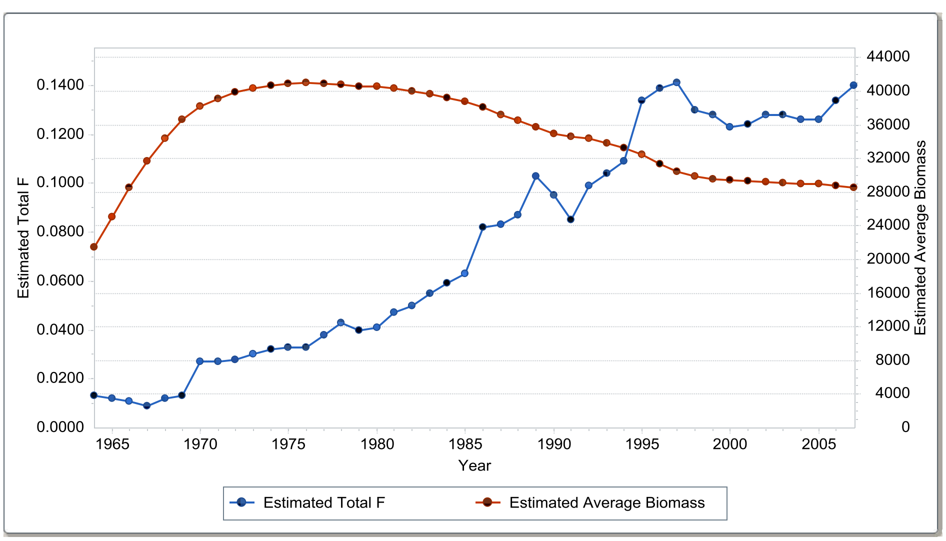


**Fig.1.14.4.4. Estimated average biomass and fishing mortality of hake in GSA 22&23 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1970-2007.**

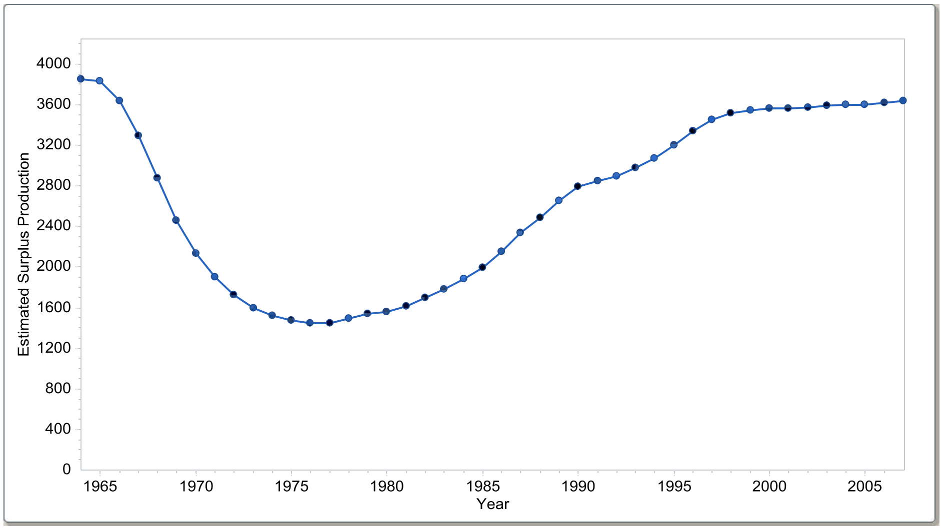



**Fig.1.14.4.5. Estimated surplus production of hake in GSA 22&23 using the dynamic non-equilibrium Logistic model in ASPIC for the period 1964-2008.**

The goodness of fit of logistic model is presented in Table 1.14.1.16.

**Table 1.14.4.16. Goodness of fit results for the logistic model in ASPIC.**

| Loss component number and title | Weighted SSE | N | Weighted MSE | Current weight | In. var. weight | R-squared CPUE |
|---|---|---|---|---|---|---|
| Loss(-1) SSE in yield | 0.00E+00 | | | | | |
| Loss(0) Penalty for B1 > K | 1.507E-01 | 1 | | 1.00E+00 | | |
| Loss(1) OTB | 4.632E+01 | 44 | 1.103E+00 | 3.077E+00 | 6.484E-01 | -0.089 |
| Loss(2) PS | 4.094E+00 | 44 | 9.749E-02 | 3.077E-01 | 7.335E-01 | 0.066 |
| Loss(3) SV | 4.095E+00 | 44 | 9.750E-02 | 3.077E-01 | 7.334E-01 | -0.289 |
| Loss(4) GTR and LLS | 1.594E+00 | 44 | 3.794E-02 | 3.077E-01 | 1.885E+00 | 0.201 |
| TOTAL OBJECTIVE FUNCTION, MSE, RMSE: | 3.616E+00 | | 5.610E+01 | 3.206E-01 | 5.662E-01 | |
| Estimated contrast index (ideal = 1.0): | 0.4664 | | C* = (Bmax-Bmin)/K | | | |
| Estimated nearness index (ideal = 1.0): | 1.000 | | N* = 1 - \|min(B-Bmsy)\|/K | | | |

The estimates of MSY, $B_{MSY}$, $F_{MSY}$, $f_{MSY}$ for each gear are shown in Table 1.14.4.17 and the estimates of MSY and $F_{MSY}$ ranges after bootstrapping using approximate 80% upper and lower confidence limits are shown in Table 1.14.4.18.

**Table 1.14.4.17. Estimated parameters of Hake in GSA 22 & 23.**

| Model | MSY (tons) | $B_{MSY}$ | $F_{MSY}$ | B(2008)/ Bmsy | F(2007)/Fmsy | $f_{MSY}$ OTB | $f_{MSY}$ PS | $f_{MSY}$ SV | $f_{MSY}$ GTR+ LLS |
|---|---|---|---|---|---|---|---|---|---|
| **Logistic** | 3.876E+03 | 2.285E+04 | 1.696E-01 | 1.239E+00 | 8.256E-01 | 3.570E+09 | 1.182E+09 | 2.909E+08 | 1.074E+08 |

**Table 1.14.4.18. Estimates of MSY and $F_{MSY}$ from bootstrapped analysis in ASPIC with confidence limits.**

| Model | MSY | | | $F_{MSY}$ | | |
|---|---|---|---|---|---|---|
| | 80% lower | | 80% higher | 80% lower | | 80% higher |
| **Logistic** | 3.876E+03 | 3.876E+03 | 3.876E+03 | 1.696E-01 | 1.696E-01 | 1.696E-01 |

The relative biomass ($B/B_{MSY}$) and fishing mortality ($F/F_{MSY}$) are showed in Figure 1.14.4.6 for the logistic model.

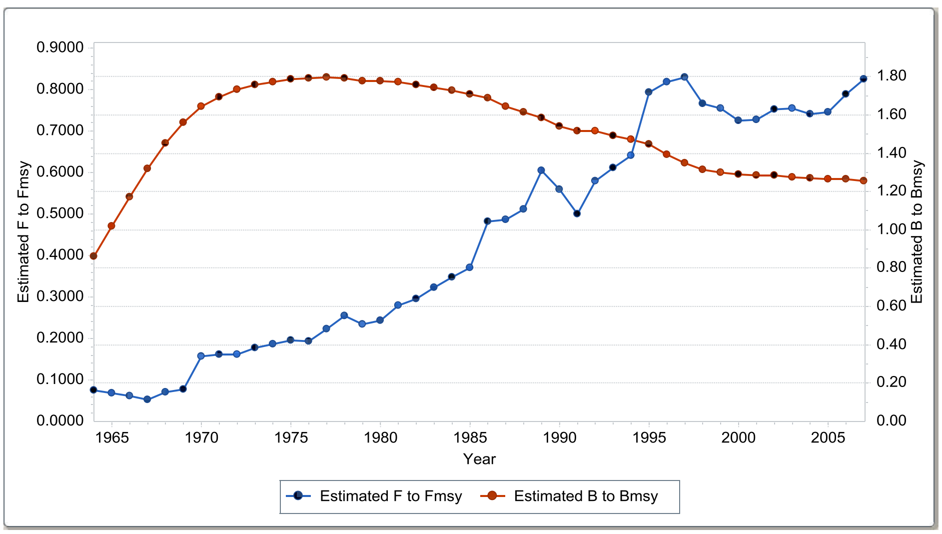



**Fig.1.14.4.6. Historic trend in estimated fishing mortality as $F/F_{MSY}$ ratio and biomass as $B/B_{MSY}$ ratio from Logistic model.**

In conclusion, the ASPIC model did not provide a good fit as well as an unrealistic low estimate of F. Thus, the EWG consider that the model output is not reliable for the assessment of hake in GSAs 22&23.

### 1.14.4.3 Method 3: SURBA (Survey Based Assessment)

***Justification***

The relatively long time series of data available from the MEDITS surveys provided the most useful data set to analyse the trend of hake stock in GSAs 22&23. The MEDITS indices of abundance (n/hour) for hake in GSA 22&23, covering the period 1994-2008 were analysed using SURBA (Survey Based stock Assessment approach, Needle, 2003). The annual standardized size distributions (1 cm length class) from MEDITS (Fig. 1.14.4.7 were converted in age distributions using the statistical slicing method approach developed during STECF EWG 11-14 (Scott et al., 2011). In each year a single age distribution was obtained for the two sexes combined.
The slicing was carried out using both the classical knife edge approach and by fitting different distributions (normal, lognormal, gamma) over the LFD data (Figs. 1.14.4.8)

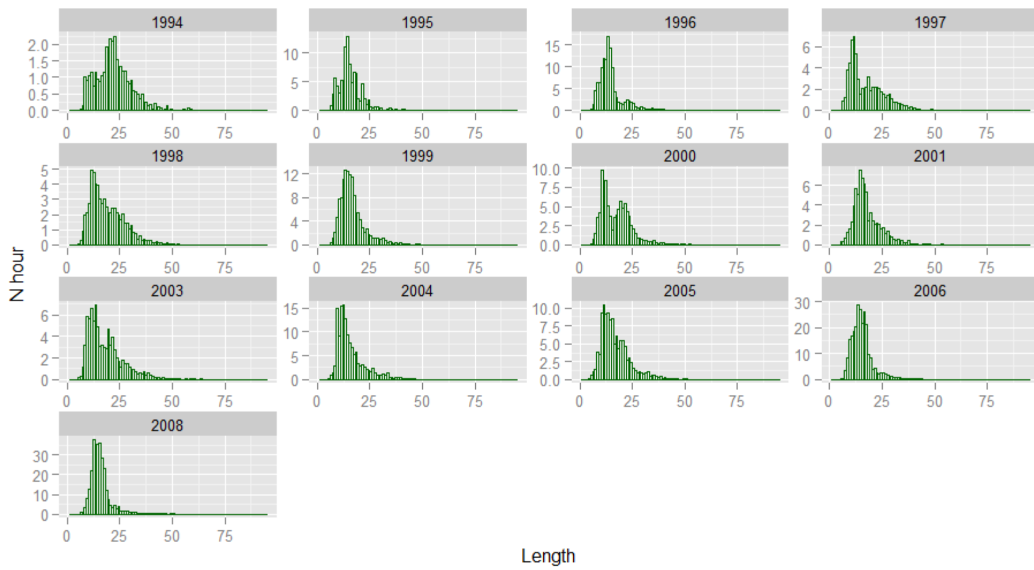
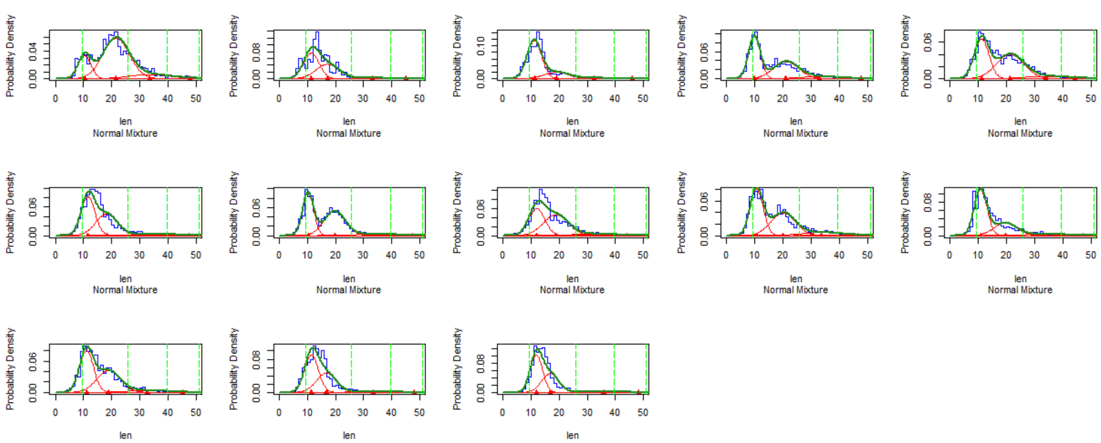
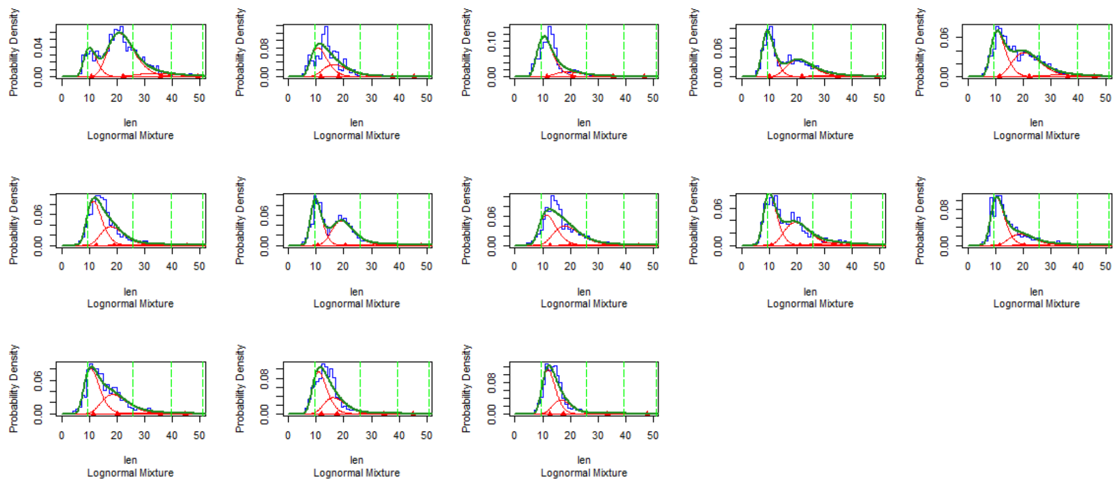



**Fig. 1.14.4.7. MEDITS length frequency distributions of hake in the GSA 22&23.**

Normal




Lognormal




Gamma distribution

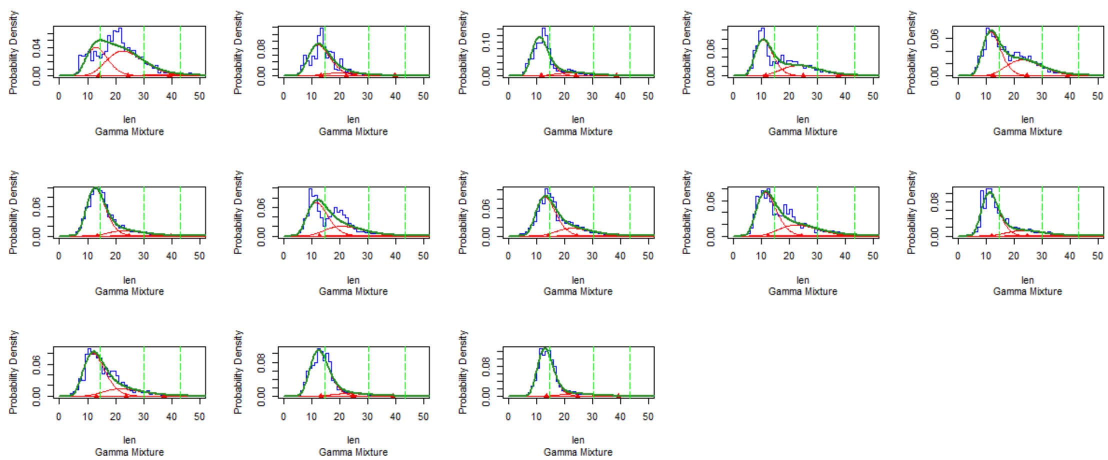



**Fig. 1.14.4.8. Result of fitting normal, lognormal and gamma distribution to 1994-2008 LFD data for hake in GSA 22&23. The red triangles on the x-axis indicates the position of mean of each distribution. The green vertical lines indicate where the von Bertalananffy growth curve places each age group. For the last three ages this coincides with the mean of the distribution because that is how we set our constraints.**

The value of chi-squared ($\chi^2$) and the degrees of freedom (df) were calculated for each distribution to compare the fits by calculating the reduced $\chi^2_{red}$, where $\chi^2_{red} = \chi^2$ /df (see Table 1.14.4.19). The adopted role of thumb is that the larger the $\chi^2_{red}$, the worse the fit. Since the better fit does not imply that the resulting estimates of mean-length-at –age are biological consistent, the final choice of the distribution depends also by the final judgement of the scientist. To this aim we have considered the reliability of the length-at age estimated by the three distributions and the consistence of the resulting cohorts.

**Table 1.14.4.19. Reduced chi-squared ($\chi^2_{red} = \chi^2/df$ ) values from fitting with the three distributions.**

| | normal | lnorm | gamma |
|---|---|---|---|
| 1994 | 0.036 | 0.027 | 0.028 |
| 1995 | 0.234 | 0.293 | 0.278 |
| 1996 | 0.119 | 0.206 | 0.184 |
| 1997 | 0.055 | 0.043 | 0.043 |
| 1998 | 0.033 | 0.037 | 0.032 |
| 1999 | 0.165 | 0.107 | 0.097 |
| 2000 | 0.041 | 0.077 | 0.059 |
| 2001 | 0.075 | 0.109 | 0.088 |
| 2003 | 0.062 | 0.058 | 0.054 |
| 2004 | 0.195 | 0.145 | 0.145 |
| 2005 | 0.075 | 0.139 | 0.099 |
| 2006 | 0.340 | 0.278 | 0.301 |
| 2008 | 0.535 | 0.360 | 0.329 |

After checking the estimated mean length at age and the fitting of the SURBA model over the different numbers-at-age matrices obtained from the statistical slicing, we decided to adopt the data matrix calculated with the knife edge slicing (Fig. 1.14.4.9). It returned the more consistent pattern, capturing the recruitment cohorts resulting from the long spawning season of the species into the first age group. The statistical slicing in most of the annual distributions attributed a high proportion of age 0 specimens into the age 1 group. In terms of mortality estimates it produced very high Z, between age 1 and 2 and a rather unstable temporal pattern.

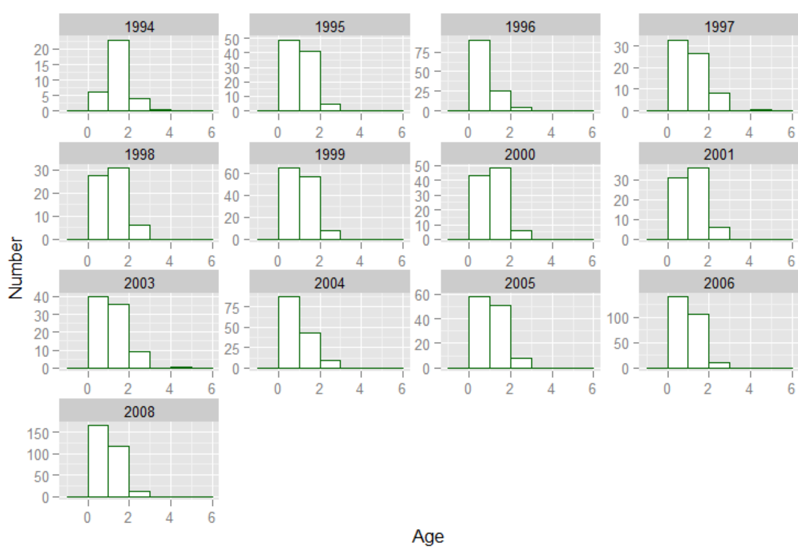



**Fig. 1.14.4.9. Numbers at age distributions of hake for MEDITS 1994-2008 in GSA 22&23 obtained by knife edge slicing.**

Input parameters

Table 1.12.4.20 shows the input parameters using to run SURBA. The age group 0 was removed from the dataset because they are not caught during Medits. The survey is generally carried out just before the recruitment period and therefore the survey catch does not include the 0 group.

Single survey exploratory SURBA 2.2 model runs were carried out fitting constant catchability (1.0 for all ages) catchability at age.

The model settings are given below:
Year range: 1994-2008, 2002 and 2007 lacking
Age range: 1-5+
Catchability: age 1 (1.0), age 2(1.0), age 3 (0.8), age 4 (0.7), age 5 (0.6)
Age weighting 1.0 at ages 1-4 , and 0.75 for age 5+
Smoothing Index Rho: 2.0
Cohort weighting: not applied

**Table 1.14.4.20. Input parameters of SURBA.**

**Growth parameters**

| Sex | L∞ | k | t0 | a | b |
|---|---|---|---|---|---|
| F+M | 110 | 0.278 | 0 | 0.0000035 | 3.024 |

**Proportion of mature**

| Age | | | | | |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5+ |
| 0 | 0.3 | 0.75 | 1 | 1 | 1 |

**Natural mortality**

| Age | | | | | |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5+ |
| 1.17 | 0.67 | 0.56 | 0.52 | 0.50 | 0.3 |

### 1.14.4.4 Results

Comparative scatterplots at age indicated a good internal consistency of the MEDITS data, except for age 4 against age 5 plus the year after (Fig. 1.14.4.10)

The trends in $F_{1\text{-}4}$, SSB and recruitment at age 0 from SURBA run, and the model residuals are given in Figures 1.14.4.11-12. The retrospectives for the MEDITS survey data are given in Figure 1.14.4.13.

The estimates can be considered reliable since 1997 when the sampling effort increased from 85-105 to 135-149 stations sampled. In the period 1997-2008 the model estimates a slight decrease in the temporal effect (f) in 1997-2004 followed by a sharp increase in 2005-2007. The age effect declines from ages 1 and 2 to ages 3-5+. SSB increased continuously whereas the recruitment shows large fluctuations in 2006-08.

The total mortality (Z) was estimated to be stable between 1.4-1.6 in 1997-2007 rising to 1.9 in 2008. $F_{1\text{-}4}$ (bootstrapped estimates) was between 0.71 and 0.87 in the period 1997-2006 increasing to 1.13 in 2007. The residuals at age do not show any major pattern.

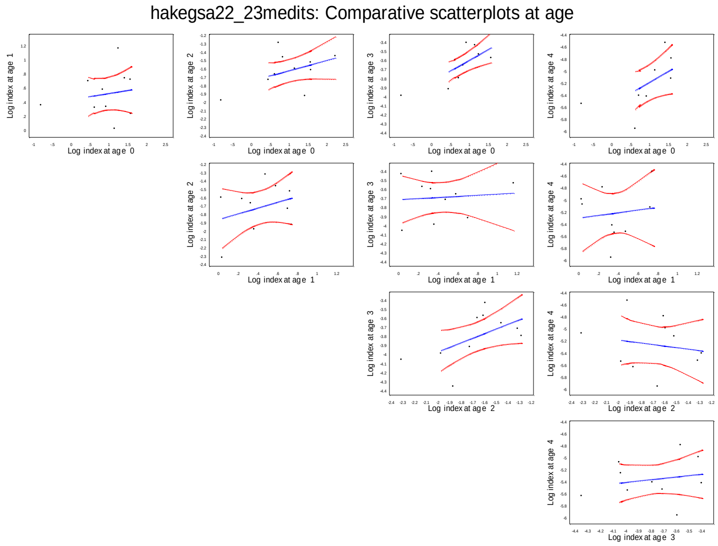
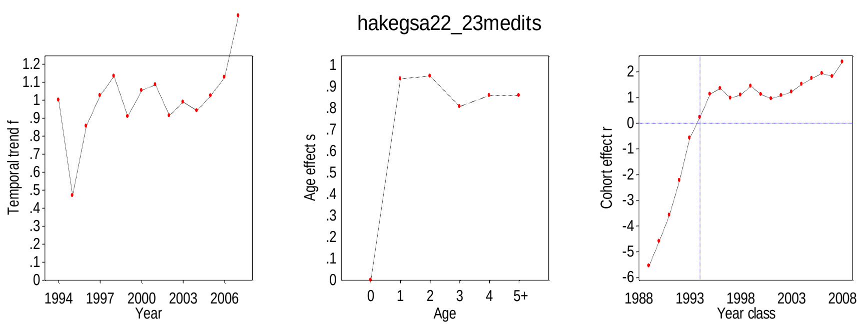
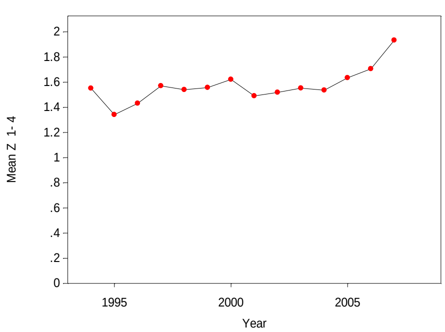



**Fig. 1.14.4.10. Hake in GSAs 22&23: Output from SURBA (ver. 2.2) plots for MEDITS survey (ages 1-5), showing age scatter plots.**

A)




B)




C)

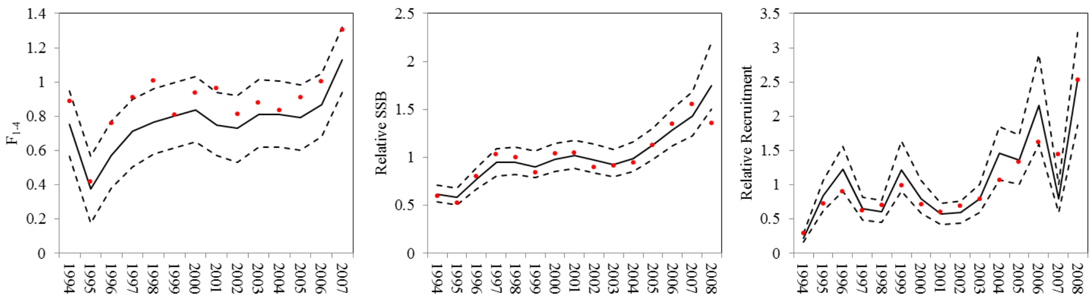
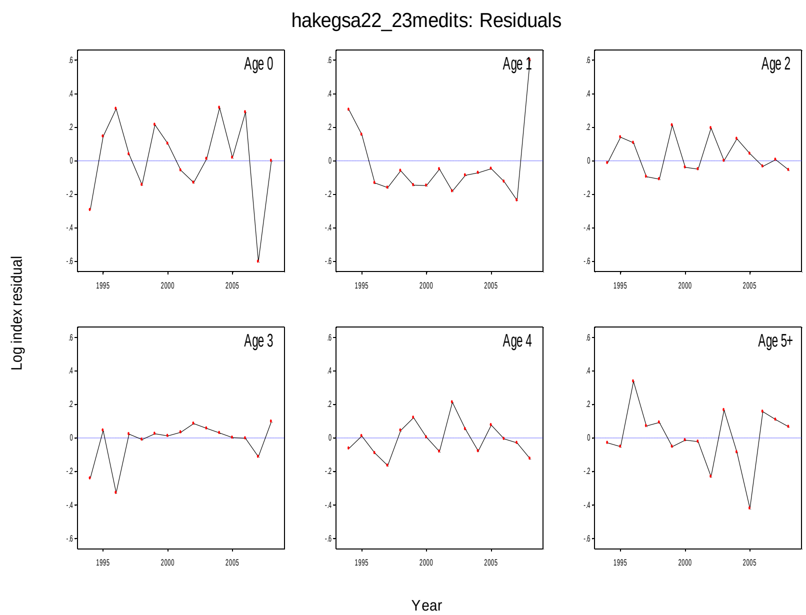



**Fig. 1.14.4.11. SURBA estimates for hake in GSAs 22&23. A) model parameters. B) total mortality ($Z_{1-4}$) c) bootstrapped (lines) and fitted (points) estimates of $F_{1-4}$, SSB, recruitment, solid and dotted lines are respectively 50% and 5- 95% of bootstrapped estimates.**

A)




B)

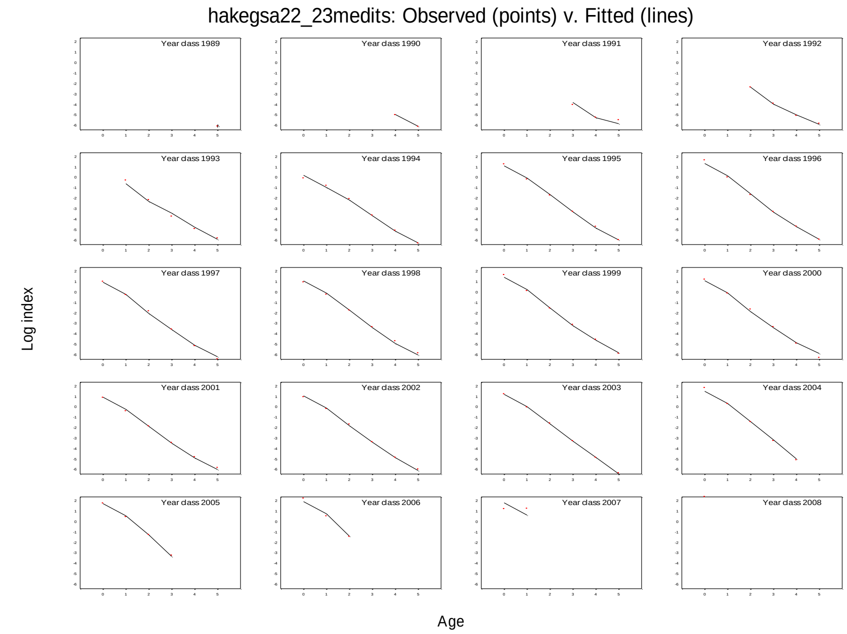



**Fig. 1.14.4.12. SURBA model diagnostic for hake in GSAs 22&23. A) Temporal trend in residuals by age B) Observed (points) and fitted (lines) year classes**

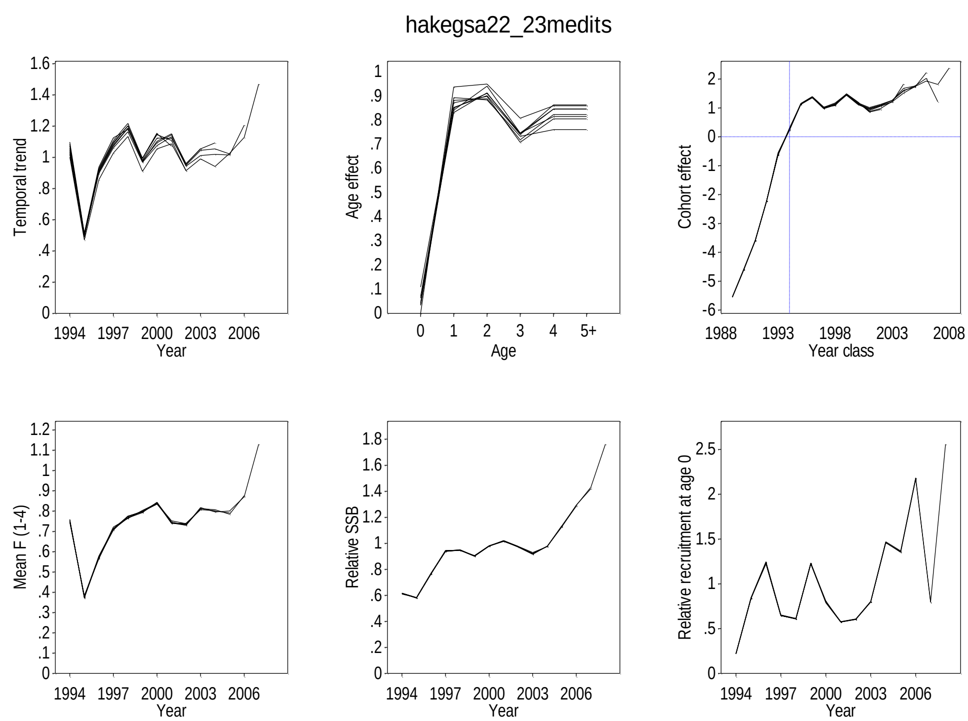



**Fig. 1.14.4.13. Hake in GSAs 22&23. SURBA model: retrospective analysis.**

### 1.14.5 *Short term prediction for 2008 and 2009*

Justification

No forecast analyses were conducted.

Input parameters

No forecast analyses were conducted.

Results

No forecast analyses were conducted.

### 1.14.6 *Medium term prediction* -

Justification

No forecast analyses were conducted.

Input parameters

No forecast analyses were conducted.

Results

No forecast analyses were conducted.

### 1.14.7 *Long term prediction*

Justification

Three YPR (yield per recruit) analyses were carried using the VIT outputs for 2004-2006.

Input parameters

The same used for the pseudocohort analyses with VIT

#### 1.14.7.1 Results

Table 1.14.7.1 and Figure 1.14.7.1 show the results of the YPR on 2004-06. The estimated $F_{01}$ factor was 0.51 in 2004 and 0.55 in 2005-06.
$F_{01}$ was 0.24 in 2004-05 and 0.25 in 2006. The corresponding $F_{01}$ for age classes 1-4 was 0.4 (average over the three years).

Table 1.14.7.1. Result of the YPR analyses on hake in GSA 22&23 for the years 2004-2006.

**2004**

| ___ | Factor | Y/R | B/R | SSB | Y/R Gear 1 | Y/R Gear 2 | Y/R Gear 3 |
|---|---|---|---|---|---|---|---|
| F(0) | 0 | 0 | 0,186 | 0,166 | 0 | 0 | 0 |
| Max Gear2 | 0,42 | 0,017 | 0,072 | 0,058 | 0,005 | 0,005 | 0,007 |
| F(0.1) | 0,51 | 0,018 | 0,058 | 0,045 | 0,005 | 0,005 | 0,008 |
| Max(:) | 0,71 | 0,018 | 0,04 | 0,029 | 0,005 | 0,004 | 0,009 |
| Max Gear1 | 0,75 | 0,018 | 0,038 | 0,027 | 0,005 | 0,004 | 0,009 |
| phi=1 | 1,01 | 0,018 | 0,025 | 0,015 | 0,005 | 0,003 | 0,009 |
| Max Gear3 | 1,24 | 0,017 | 0,018 | 0,01 | 0,005 | 0,002 | 0,01 |
| phi=2 | 2 | 0,014 | 0,009 | 0,003 | 0,004 | 0,001 | 0,009 |

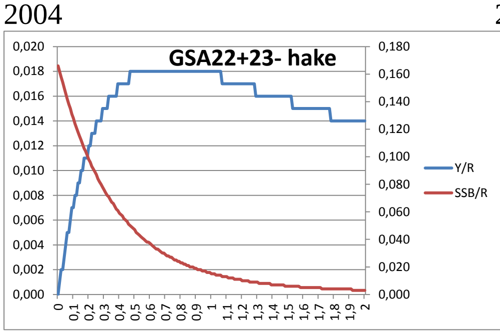
**2005**

| ___ | Factor | Y/R | B/R | SSB | Y/R Gear 1 | Y/R Gear 2 | Y/R Gear 3 |
|---|---|---|---|---|---|---|---|
| F(0) | 0 | 0 | 0,186 | 0,166 | 0 | 0 | 0 |
| Max Gear2 | 0,43 | 0,018 | 0,079 | 0,064 | 0,005 | 0,006 | 0,007 |
| F(0.1) | 0,55 | 0,019 | 0,062 | 0,049 | 0,005 | 0,005 | 0,008 |
| Max(:) | 0,76 | 0,02 | 0,044 | 0,032 | 0,006 | 0,005 | 0,009 |
| Max Gear1 | 0,94 | 0,019 | 0,034 | 0,023 | 0,006 | 0,004 | 0,01 |
| phi=1 | 1,01 | 0,019 | 0,031 | 0,02 | 0,006 | 0,003 | 0,01 |
| Max Gear3 | 1,35 | 0,018 | 0,02 | 0,011 | 0,006 | 0,002 | 0,01 |
| phi=2 | 2 | 0,015 | 0,012 | 0,005 | 0,004 | 0,001 | 0,01 |

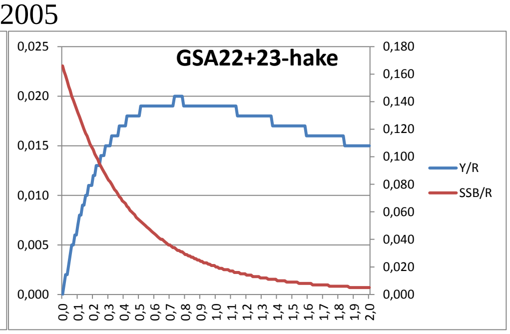
**2006**

| ___ | Factor | Y/R | B/R | SSB | Y/R Gear 1 | Y/R Gear 2 | Y/R Gear 3 |
|---|---|---|---|---|---|---|---|
| F(0) | 0 | 0 | 0,186 | 0,166 | 0 | 0 | 0 |
| Max Gear2 | 0,43 | 0,018 | 0,079 | 0,064 | 0,005 | 0,006 | 0,007 |
| F(0.1) | 0,55 | 0,019 | 0,062 | 0,049 | 0,005 | 0,005 | 0,008 |
| Max(:) | 0,76 | 0,02 | 0,044 | 0,032 | 0,006 | 0,005 | 0,009 |
| Max Gear1 | 0,94 | 0,019 | 0,034 | 0,023 | 0,006 | 0,004 | 0,01 |
| phi=1 | 1,01 | 0,019 | 0,031 | 0,02 | 0,006 | 0,003 | 0,01 |
| Max Gear3 | 1,35 | 0,018 | 0,02 | 0,011 | 0,006 | 0,002 | 0,01 |
| phi=2 | 2 | 0,015 | 0,012 | 0,005 | 0,004 | 0,001 | 0,01 |

2004




2005




2006

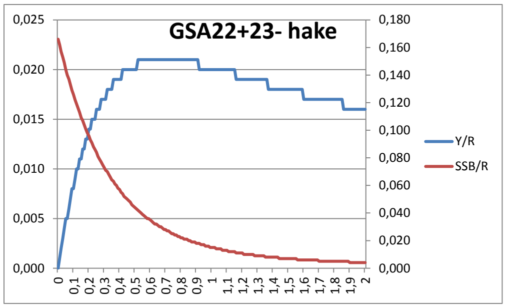
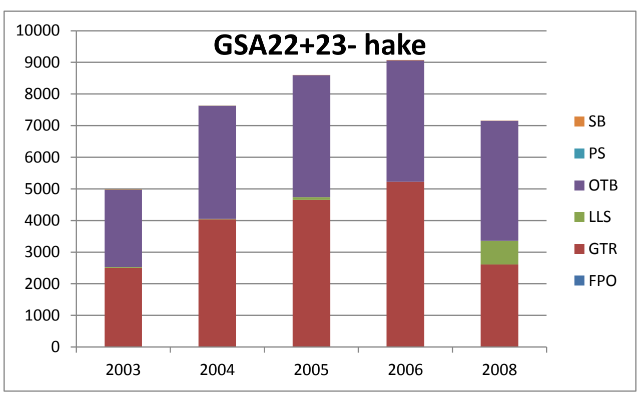



Fig. 1.14.7.1. YPR outputs. YPR(left axis) and SSB/R (right axis), in grams, for hake in GSA22&23 in 2004-06. Note that x- axis indicates factor (not Fvalue).

### 1.14.8 *Data quality*

Data used in the LCA were taken from the access database "SGMED 2009 fisheries data 20100118GRConly". A number of gaps and inconsistencies were found in the DCR Fisheries data, which determined the years that could be used as input for LCA. The main problem is that landings data by gear taken from the database or calculated from the size distributions by gear are rather different, due to the lack of data on sizes (Fig. 1.14.8.1-2). For this reason, the annual size distributions were very different. The years with more complete data, 2004, 2005 and 2006, were chosen as input for LCA.

No data on discards available and no data for 2007.



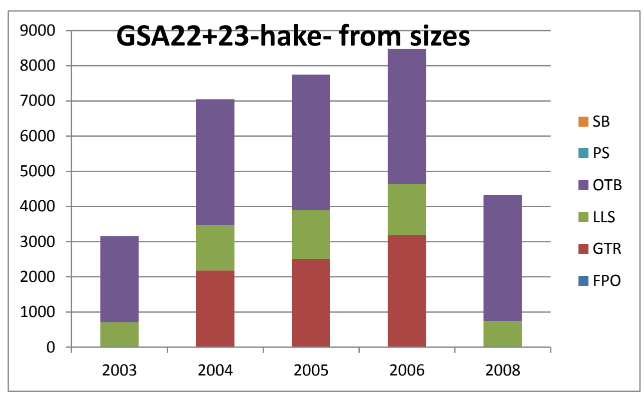




Fig. 1.14.8.1. Hake annual landings (t) in GSA22&23, as taken from the access database (left) and calculated from the annual size distributions by gear (rigth).

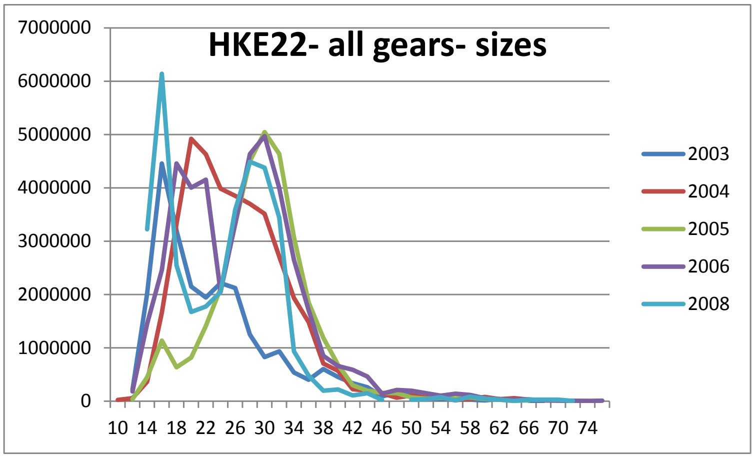



Fig. 1.14.8.2. Hake annual size distributions (numbers) in GSA22&23 (data source: access database)

## 1.14.9 *Scientific advice*

### 1.14.9.1 Short term considerations

#### 1.14.9.1.1 State of the stock size

Stock assessment has been computed by Length Cohort Analysis (VIT software) using as input DCR data of the annual length distributions of 2004-06. The estimated SSB ranged between 5600 and 7818 t. The production model (ASPIC) did not return a reliable pattern in the stock trend. SURBA analysis of the MEDITS data (1994-08) showed an increasing trend in SSB since 1994.

Since no biomass reference levels for the stock of hake in GSA 22&23 were proposed, STECF ad-hoc WG for the assessment of Greek stocks cannot evaluate the stock status in relation to these.

#### 1.14.9.1.2 State of recruitment

SURBA analysis of the MEDITS data (1994-08) showed large fluctuations with an increasing since 2003.

#### 1.14.9.1.3 State of exploitation

STECF ad-hoc WG for the assessment of Greek stocks proposes $F_{0.1} \leq 0.24$ as proxy of $F_{MSY}$.

The current $F_{1-4}$ was between 0.67 and 0.83 in 2004-06 and therefore larger than $F_{MSY}$. The survey data (SURBA analysis) indicated an increasing pattern in $F_{1-4}$ since 1995. The SURBA estimates for $F_{1-4}$ were between 0.79 and 0.86 in 2004-06 and 1.1 in 2007. Based on the LCA assessment, STECF ad-hoc WG for the assessment of Greek stocks considers the stock of hake in the GSA 22&23 exploited unsustainably until 2007.

Section 3

**Summary sheets**

1.15 **Summary sheet of blotched picarel (*Spicara flexuosa*) in GSA 20**

| | |
|---|---|
| Species common name: | Blotched picarel |
| Species scientific name | *Spicara flexuosa* |
| Geographical Sub-area(s) GSA(s): | GSA 20 |

**Most recent state of the stock**

- State of the adult abundance and biomass:

The results of the short time series of data do not allow concluding on reference points of $B_{lim}$ or $B_{pa}$. In the absence of proposed or agreed references, STECF Ad-hoc working group on the assessment of some Greek stocks is unable to fully evaluate the state of the stock and provide scientific advice. Based on SURBA results an increase in the SSB is observed up to 2006 with a fall afterwards. No absolute estimates are possible since SURBA output is a relative index of SSB.

The results of the production models suggest that the biomass at sea is around higher than the $B_{MSY}$ ($B/B_{MSY}$ = 1.58).

- State of the juvenile (recruits):

SURBA model results showed an increase in recruitment up to 2003 and a decrease since then up to 2008. No absolute estimates are possible since SURBA output is a relative index of recruitment.

- State of exploitation:

Based on SURBA, the mean fishing mortality (averaged over ages 1 to 3) shows no apparent trend being on average around 0.8 for the studied period. It is important to notice that SURBA provide useful information on the trend of F and not on its absolute value, as long as it is not possible to verify if selection at age of the MEDITS is comparable with these of the commercial gears. However, considering that SSB increases, STECF Ad-hoc working group on the assessment of some Greek stocks concludes that the current level of exploitation is not detrimental to the stock.

The results of the production models suggest that blotched picarel in the GSA 20 is sustainably exploited, considering that the current F is below the $F_{MSY}$ in both ASPIC models ($F/F_{MSY}$ = 0.42).

Due to the low amount of landings observed for the other fisheries, the model has been run only using trawl. Such decision provided better fit and more realistic values of $F_{MSY}$ and $B_{MSY}$, although they can be respectively slightly overestimated and underestimated.

- Source of data and methods:

(a) survey-based (MEDITS) stock assessment approach SURBA
(b) A non-equilibrium dynamic biomass model incorporating covariates [ASPIC 5.10.1] (Prager 2005) was applied to catch and effort (hP x Days) data from the GSAs 20, of the two main fishing fleet exploiting blotched picarel. Three model shapes, namely: Logistic, Fox and the Generalized Estimate Exponent were used.In addition to data on catch and effort, ASPIC requires starting guesses and ranges for the parameters to be estimated by the model: carring capacity (K), maximum sustainable yield (MSY), the ratio of the biomass at the beginning of the first year to the carrying capacity (B1/K) and catchability (*q*). Due to the low amount of landings observed for the other fisheries, the model has been run only using trawl. Such decision provided better fit and more realistic values of $F_{MSY}$ and MSY, although they can be respectively slightly overestimated and underestimated.

**Outlook and management advice**

**Fisheries**

**Limit and precautionary management reference points**

| | |
|---|---|
| $F_{0.1}$ (mean) | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

| | |
|---|---|
| $F_{0.1}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

**Comments on the assessment**

The detailed assessment of blotched picarel in GSA 20 can be found in section 2 (1.1) of this report.

## 1.16 **Summary sheet of blotched picarel (*Spicara flexuosa*) in GSA 22&23**

| | |
|---|---|
| Species common name: | Blotched picarel |
| Species scientific name | *Spicara flexuosa* |
| Geographical Sub-area(s) GSA(s): | 22&23 |

**Most recent state of the stock**

- <u>State of the adult abundance and biomass:</u>

The results of the short time series of data do not allow concluding on reference points of $B_{lim}$ or $B_{pa}$. In the absence of proposed or agreed references, STECF Ad-hoc working group on the assessment of some Greek stocks is unable to fully evaluate the state of the stock and provide scientific advice.

ASPIC results showed the biomass at sea is below the $B_{MSY}$, with the current biomass being around 60% of the $B_{MSY}$ ($B/B_{MSY} = 0.60$).

Based on SURBA results an increase in the SSB is observed since 2001, however the lack of data after 2008 prevents the verification of the model output. No absolute estimates are possible since SURBA output is a relative index of SSB.

- <u>State of the juvenile (recruits):</u>

SURBA model showed an increase in recruitment up to 2003 and a decrease since then up to 2008. No absolute estimates are possible since SURBA output is a relative index of recruitment.

- <u>State of exploitation:</u>

Based on SURBA, the mean fishing mortality (averaged over ages 1 to 3) is highly variable but showed a clear decreasing trend since 2005. It is important to notice that SURBA provide useful information on the trend of F and not on its absolute value, as long as it is not possible to verify if selection at age of the MEDITS is comparable with these of the commercial gears.

The results of the production models suggest that blotched picarel in GSA 22&23 is not exploited sustainably, since current F estimated in the ASPIC model is around 1.25 times the $F_{MSY}$ ($F/F_{MSY} = 1.25$).

- <u>Source of data and methods:</u>

(c) survey-based (MEDITS) stock assessment approach SURBA.

b) A non-equilibrium dynamic biomass model incorporating covariates [ASPIC 5.10.1] (Prager 2005) was applied to catch and effort (hP x Days) data from the GSAs 22 and 23, of the two main fishing fleet exploiting blotched picarel. Three model shapes, namely: Logistic, Fox and the Generalized Estimate Exponent were used.

In addition to data on catch and effort, ASPIC requires starting guesses and ranges for the parameters to be estimated by the model: carring capacity (K), maximum sustainable yield (MSY), the ratio of the biomass at the beginning of the first year to the carrying capacity (B1/K) and catchability (q). Due to the low amount of landings observed for the other fisheries, the model has been run only using small scale vessels. Such decision provided better fit and more realistic values of FMSY and MSY, although they can be respectively slightly overestimated and underestimated.

## Outlook and management advice

EWG emphasizes that this is the first attempt to evaluate the exploitation state of the species using production model, therefore, it is necessary to analyze with other approach in order to confirm the results obtained for 2007 and 2008. However, the current assessment indicated that the stock is exploited sustainably and the biomass is larger than the biomass at MSY.

## Fisheries

## Limit and precautionary management reference points

| | |
|---|---|
| $F_{0.1}$ (mean) | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

| | |
|---|---|
| $F_{0.1}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

## Comments on the assessment

The detailed assessment of blotched picarel in GSA 22&23 can be found in section 2 (1.2) of this report.

## 1.17 **Summary sheet of picarel (*Spicara smaris*) in GSA 20**

| | |
|---|---|
| Species common name: | Picarel |
| Species scientific name | *Spicara smaris* |
| Geographical Sub-area(s) GSA(s): | 20 |

**Most recent state of the stock**

- <u>State of the adult abundance and biomass:</u>

In the absence of proposed or agreed precautionary refernce is not possible to fully evaluate the status of the spawning stock size. In the current stock assessment, SURBA results are not considered reliable.
The biomass at sea is recovering after a period of low values estimated between 1995 and 2005. The total biomass at sea in 2008 estimated with the production model using the Fox approach is 1.15 times $B_{MSY}$ ($B/B_{MSY}$ = 1.15).

- <u>State of the juvenile (recruits):</u>

Is not possible to provide any scientific advice of the state of the recruitment as no trend in recruitment is evident in SURBA. In addition SURBA model presented poor data fit and is not considered reliable.

- <u>State of exploitation:</u>

The results from ASPIC suggests that the stock is exploited sustainably ($F/F_{MSY}$ = 0.30). SURBA results, due to the poor fit, are not considered reliable to evaluate the status of the exploitation.

- <u>Source of data and methods:</u>

A non-equilibrium dynamic biomass model incorporating covariates [ASPIC 5.10.1] (Prager 2005) was applied to catch and effort (hP x Days) data from the GSA 20, of the four fishing fleet exploiting picarel. Three model shapes, namely: Logistic, Fox and the Generalized Estimate Exponent were used.

In addition to data on catch and effort, ASPIC requires starting guesses and ranges for the parameters to be estimated by the model: carring capacity (K), maximum sustainable yield (MSY), the ratio of the biomass at the beginning of the first year to the carrying capacity (B1/K) and catchability (q).

Moreover, the survey-based stock assessment approach SURBA (Needle, 2003) was used on MEDITS (1994-2009) data for *S. smaris* in GSAs 20. Length was converted to ages based on the growth equation presented in Tab. 1.1.4.1.2.1 for both sexes (Tsangridis, and Filippousis, 1991).

**Outlook and management advice**

EWG emphasizes that this is the first attempt to evaluate the exploitation state of the species using production model and SURBA and, therefore, it is necessary to analyze with other approach in order to confirm the results obtained for 2007 and 2008. However, the current assessment indicated that the stock is exploited sustainably and the biomass is larger than the biomass at MSY.

**Fisheries**

During the years 1970 - 2008 the mean annual Mediterranean production of the picarel was 13 thousand tonnes. More than 50% of the total annual Mediterranean production was caught in Greek seas. In the Ionian sea the avarage landings of picarel is around 1,500 tons (FAO-FISHSTAT GFCM database, 2011).

The species in the Ionian sea is mainly caught by beach seines and trawlers, while only a small quantity is landed by the artisanal fishery and purse seine (Moutopoulos and Stergiou, 2012), with landings comprised between 400 and 2,200 tons. The Neighborhood country landings (Albania; FAO-FISHSTAT GFCM database) of picarel are quite low (on average around 5 tons in the last three years), so it is possible to assume that the stock inhabiting the GSA 20 is mainly exploited by the greek fleets.

**Limit and precautionary management reference points**

| | |
|---|---|
| $F_{0.1}$ (mean) | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

| | |
|---|---|
| $F_{0.1}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

**Comments on the assessment**

The detailed assessment of picarel in GSA 20 can be found in section 2 (1.3) of this report.

## 1.18 **Summary sheet of picarel (*Spicara smaris*) in GSA 22&23**

| | |
|---|---|
| Species common name: | Picarel |
| Species scientific name | *Spicara smaris* |
| Geographical Sub-area(s) GSA(s): | 22&23 |

**Most recent state of the stock**

- State of the adult abundance and biomass:

In the absence of proposed or agreed precautionary reference is not possible to fully evaluate the status of the spawning stock size. SURBA results, due to the poor data fit, are not considered reliable to evalute the status of the spawning stock size.

The total biomass at sea in 2008 estimated with the production model using the Fox approach, is about 20% of $B_{MSY}$ ($B/B_{MSY}$ = 0.21).

- State of the juvenile (recruits):

SURBA results, due to the poor data fit, are not considered reliable to evalute the status of the recruitment.

- State of exploitation:

The values of current F estimated by ASPIC ($F/F_{MSY}$ = 1.67) suggests that picarel in GSA 22&23 is exploited unsustainably. SURBA results due to the poor fit, are not considered reliable to evalute the status of the exploitation.

- Source of data and methods:

A non-equilibrium dynamic biomass model incorporating covariates [ASPIC 5.10.1] (Prager 2005) was applied to catch and effort (hP x Days) data from the GSAs 22 & 23, of the four fishing fleet exploiting picarel. Three model shapes, namely: Logistic, Fox and the Generalized Estimate Exponent were used. In addition to data on catch and effort, ASPIC requires starting guesses and ranges for the parameters to be estimated by the model: carring capacity (K), maximum sustainable yield (MSY), the ratio of the biomass at the beginning of the first year to the carrying capacity (B1/K) and catchability (q). Moreover, the survey-based stock assessment approach SURBA (Needle, 2003) was used on MEDITS (1994-2009) data for *S. smaris* in GSAs 22-23. Length was converted to ages based on the growth equation presented in Tab. 1.1.4.1.2.1 for both sexes (Tsangridis and Filippousis, 1991).

**Outlook and management advice**

EWG recommends to reduce fishing mortality towards the proposed reference point $F_{MSY}$ in order to avoid future losses in stock productivity and allow the increase of the biomass at sea above the $B_{MSY}$. This can be done by reducing the effort or the catches of the fleets that exploit the stock, by means of a multi-annual management plan taking into account mixed-fisheries effects of some of the fleets.

EWG emphasizes that this is the first attempt to evaluate the exploitation state of the species using production model and SURBA and, therefore, it is necessary to analyze with other approach in order to confirm the results obtained.

**Comments on the assessment**
The detailed assessment of picarel in GSA 22&23 can be found in section 2 (1.4) of this report.

**Limit and precautionary management reference points**

| | |
|---|---|
| $F_{0.1}$ (mean) | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

| | |
|---|---|
| $F_{0.1}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

## 1.19 Summary sheet of bogue (Boops boops) in GSA 20

| | |
|---|---|
| Species common name: | Bogue |
| Species scientific name | *Boops boops* |
| Geographical Sub-area(s) GSA(s): | GSA 20 |

**Most recent state of the stock**

- State of the adult abundance and biomass:

In the absence of proposed or agreed precautionary reference is not possible to fully evaluate the status of the spawning stock size. The applied SURBA model based on MEDITS survey exhibited poor data fit and was not evaluated as reliable to identify trends in total biomass for bogue in GSA 20.

Surplus Production model did not present adequate data fot and was not considered reliable for the stock assessment of bogue in GSA 20. In the absence of a precautionary reference point and reliable stock assessment estimates the EWG is unable to evaluate the status of the stock size.

- State of the juvenile (recruits):

SURBA results were not considered reliable in terms of recruitment status. In the absence of reliable results the EWG is unable to fully evaluate the status of the state of juveniles.

- State of exploitation:

SURBA results were not considered reliable to evaluate the exploitation status of the stock.

The Surplus Production model did not present adequate data and it was not considered reliable for the stock assessment of bogue in GSA 20. Thus, the EWG is unable to evaluate the exploitation status of bogue in GSA 20.

- Source of data and methods:

A non-equilibrium dynamic biomass model incorporating covariates [ASPIC 5.10.1] (Prager 2005) was applied to catch and effort (hP x Days) data from the GSA 20 of three fishing fleets that are responsible for the majority of bogue catches. The Logistic model was used.

In addition to data on catch and effort, ASPIC requires starting guesses and ranges for the parameters to be estimated by the model: carrying capacity (K), maximum sustainable yield (MSY), the ratio of the biomass at the beginning of the first year to the carrying capacity (B1/K) and catchability (q). Data on catches and directed fishing effort provided to the WG derived from EVOMED data, data from Moutopoulos and Stergiou (2012) and data to FAO GFCM and DCF were used for this purpose. A dynamic Biomass Production model (ASPIC) using a time series from 1994 and 2008 of catch and effort of commercial vessels concerning 3 different fleets i.e. purse seines, small scale boats and trawls was applied.
Moreover, the survey-based stock assessment approach SURBA (Needle, 2003) was used on MEDITS (1994-2009) data for *bogue* in GSA 20. Length was converted to ages based on the growth equation presented in section 2.1.1.2 of the report for both sexes (Kallianiotis 1992).

**Outlook and management advice**

EWG emphasizes that this is the first attempt to evaluate the exploitation state of the species using production model and SURBA. No reliable estimate concerning the stock status was obtained so suitable data are needed to allow the implementation of a VPA based model, to evaluate stock status.

**Fisheries**

The species is mainly exploited by artisanal boats, purse seines and to a lesser degree by bottom trawlers and beach seines. Annual landings of bogue in GSA 20 are on average at 1000 tons over the period 2000-2008. No data on the length and age structure of landings is available.

**Limit and precautionary management reference points**

No limit and precautionary management reference points are proposed by STECF Ad hoc Working Group.

| | |
|---|---|
| $F_{0.1}$ (mean) | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{0.1}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

**Comments on the assessment**

The detailed assessment of bogue in GSA 20 can be found in section 2 (1.5) of this report.

## 1.20 Summary sheet of bogue (Boops boops) in GSA 22&23

| | |
|---|---|
| Species common name: | Bogue |
| Species scientific name | *Boops boops* |
| Geographical Sub-area(s) GSA(s): | GSA 22&23 |

**Most recent state of the stock**

- State of the adult abundance and biomass:

In the absence of proposed or agreed precautionary reference is not possible to fully evaluate the status of the spawning stock size. The applied SURBA model based on MEDITS survey exhibited poor data fit and was not evaluated as reliable to identify trends in total biomass for bogue in GSA 22&23.
Surplus Production model (ASPIC) results indicated that $B_{curr}/B_{MSY}$ ratio (for 2008) is 0.66.

- State of the juvenile (recruits):

In the current stock assessment SURBA results due to the poor data fit were not considered reliable to evalute the recruitment status and identify any trends. In the absence of reliable results it is not possible to fully evaluate the status of the state of juveniles.

- State of exploitation:

SURBA results due to poor data fit were not considered reliable to evaluate the exploitation status of the stock.

The Surplus Production model results indicated that the stock is exploited sustainably ($F/F_{MSY}$=0.62).

- Source of data and methods:

A non-equilibrium dynamic biomass model incorporating covariates [ASPIC 5.10.1] (Prager 2005) was applied to catch and effort (hP x Days) data from the GSAs 22 and 23, of the three fishing fleets that responsible for the majority of bogue catches. The Logistic model was used.
In addition to data on catch and effort, ASPIC requires starting guesses and ranges for the parameters to be estimated by the model: carrying capacity (K), maximum sustainable yield (MSY), the ratio of the biomass at the beginning of the first year to the carrying capacity (B1/K) and catchability (q). Data on catches and directed fishing effort provided to the WG derived from EVOMED data, data from Moutopoulos and Stergiou (2012) and data to FAO GFCM and DCF were used for this purpose. ASPIC used a time series from 1994 and 2008 of catch and effort of commercial vessels concerning 3 different fleets i.e. purse seines, small scale boats and beach seines.
Moreover, the survey-based stock assessment approach SURBA (Needle, 2003) was used on MEDITS (1994-2009) data for *bogue* in GSAs 22-23. Length was converted to ages based on the growth equation estimated by Stergiou et al., (2004).

**Outlook and management advice**

Considering the uncertainities related with the estimates of production models, and the period 1964-1974 characterized by higher levels of biomass at sea, is suggested, to maintain the same level of exploitation for the following years, in order to avoid future losses in stock productivity and allow the increase of the biomass at sea above the $B_{MSY}$. EWG emphasizes that this is the first attempt to evaluate the exploitation state of the species using production model and SURBA and, therefore, it is necessary to analyze with other approach in order to confirm the results obtained for 2008. Suitable data are needed to allow the implementation of a VPA based model, to fully evaluate stock status.

## Fisheries

The species is mainly exploited by artisanal boats, purse seines and to a lesser degree by bottom trawlers and beach seines. Annual landings of bogue in GSA 22&23 are on average at 3600 tons over the period 2000-2007. No data on the length and age structure of landings is available.

**Limit and precautionary management reference points**

Table of limit and precautionary management reference points proposed by EWG

| | |
|---|---|
| $F_{0.1}$ (mean) | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{0.1}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

**Comments on the assessment**

The detailed assessment of bogue in GSA 22&23 can be found in section 2 (1.6) of this report.

## 1.21 **Summary sheet of Norway lobster (*Nephrops norvegicus*) in GSA 20**

| | |
|---|---|
| Species common name: | Norway lobster |
| Species scientific name | *Nephrops norvegicus* |
| Geographical Sub-area(s) GSA(s): | 20 |

**Most recent state of the stock**

- <u>State of the adult abundance and biomass:</u>

According to the SURBA analysis, SSB shows a marked decreasing trend over the data series analysed. ASPIC results showed that $B/B_{MSY}$ for 2008 being 0.18, i.e. about 20 of the $B_{MSY}$. It is important to notice that SURBA provide useful information on the trend of SSB and not on its absolute value, as long as it is not possible to verify if selection at age of the MEDITS is comparable with these of the commercial gears.

- <u>State of the juvenile (recruits):</u>

According to the SURBA analysis the recruitment of Norway lobster in GSA 20 showed a decreasing trend. It is important to notice that SURBA provide useful information on the trend of recruitment and not on its absolute value.

- <u>State of exploitation:</u>

Based on SURBA, fishing mortality showed some oscillations along the data series analysed. The results of the production model suggest that *Nephrops norvegicus* in GSA 20 is an overexploited stage, considering that the current F is 2.065 times above the $F_{MSY}$ ($F/F_{MSY}$ = 2.06). However, ASPIC results might not be reliable and should be considered with caution. It is important to notice that SURBA provide useful information on the trend of F and not on its absolute value, as long as it is not possible to verify if selection at age of the MEDITS is comparable with these of the commercial gears.

- <u>Source of data and methods:</u>

(d) survey-based (MEDITS) stock assessment approach SURBA.
(b) Input data consists of 2 sets of time series of total landings (in t) and standardized fishing effort expressed as fishing days * total HP for GSA 20 for small scale gears GNS+LLS and trawls OTB. Landings for both gears refer to the period 1970-2007 due to zero landings during 1964-1969. The possibility of using at the same time several data sets is a new extension incorporated in the ASPIC new versions. The analysis was performed using the ASPIC.5.3 software (A Stock-Production model Incorporating Covariates) (Prager, 1994, 2005) assuming a Schaefer (1954) model. This program implements a nonequilibrium, continuous-time, observation-error estimator for the dynamic production model (Schnute, 1977; Prager, 1994). The model was used to estimate K, MSY, the ratios of both current biomass or F to the biomass or F at which MSY can be attained, and q (the catchability coefficient, the proportion of total stock removed by one unit of fishing effort).

## Outlook and management advice

EWG recommends to reduce fishing mortality towards the proposed reference point $F_{MSY}$ in order to avoid future losses in stock productivity and allow the increase of the biomass at sea above the $B_{MSY}$. This can be done by reducing the effort or the catches of the fleets that exploit the stock, by means of a multi-annual management plan taking into account mixed-fisheries effects of some of the fleets.

EWG emphasizes that this is the first attempt to evaluate the exploitation state of the species using production model and SURBA and, therefore, it is necessary to analyze with other approach in order to confirm the results obtained for 2007 and 2008.

## Fisheries

## Limit and precautionary management reference points

| | |
|---|---|
| $F_{0.1}$ (mean) | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

| | |
|---|---|
| $F_{0.1}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

## Comments on the assessment

The detailed assessment of Norway lobster in GSA20 can be found in section 2 (1.7) of this report.

## 1.22 **Summary sheet of Norway lobster (*Nephrops norvegicus*) in GSA 22&23**

| | |
|---|---|
| Species common name: | Norway lobster |
| Species scientific name | *Nephrops norvegicus* |
| Geographical Sub-area(s) GSA(s): | 22&23 |

**Most recent state of the stock**

- State of the adult abundance and biomass:

According to the SURBA analysis, SSB shows a marked decreasing trend over the data series analysed. ASPIC results showed that $B/B_{MSY}$ for 2008 being 0.63, i.e. below the estimated $B_{MSY}$. It is important to notice that SURBA provide useful information on the trend of SSB and not on its absolute value, as long as it is not possible to verify if selection at age of the MEDITS is comparable with these of the commercial gears.

- State of the juvenile (recruits):

According to the SURBA analysis the recruitment of Norway lobster in GSA 22&23 showed an increasing trend during the first years, reaching later certain stability with a slightly decreasing trend. It is important to notice that SURBA provide useful information on the trend of recruitment and not on its absolute value.

- State of exploitation:

Based on SURBA, fishing mortality showed small oscillations along the data series analysed with a slightly increasing trend.

The results of the production model suggest that *Nephrops norvegicus* in GSA 22&23 is exploited unsustainably, considering that the current F is 1.6 times above the $F_{MSY}$ ($F/F_{MSY}$ = 1.613). However, ASPIC results might not be reliable and should be considered with caution. It is important to notice that SURBA provide useful information on the trend of F and not on its absolute value, as long as it is not possible to verify if selection at age of the MEDITS is comparable with these of the commercial gears.

- Source of data and methods:

(a) Length cohort analysis (LCA, VIT software) was used on an annual pseudocohort for the years 2003, 2004, 2005, 2006 and 2008. Catch at length data in GSA 22-23 were provided according to the 2009 Greek Official EC Data Call.
(b) Landings data from OTB were not used in the model due to low values and the presence of zero landings. In addition data for GNS+LLS were referred to the period 1970-2007 due to zero landings during 1964-1969. The logistic model was used. In addition to data on catch and effort, ASPIC requires starting guesses and ranges for the parameters to be estimated by the model: carring capacity (K), maximum sustainable yield (MSY), the ratio of the biomass at the beginning of the first year to the carrying capacity (B1/K) and catchability (q).

(c) Survey-based stock assessment approach SURBA was applied to MEDITS data for the period 1994-2008 (excluding 2002 and 2007).

**Outlook and management advice**

EWG recommends to reduce fishing mortality towards the proposed reference point $F_{MSY}$ in order to avoid future losses in stock productivity and allow the increase of the biomass at sea above the $B_{MSY}$. This can be done by reducing the effort or the catches of the fleets that exploit the stock, by means of a multi-annual management plan taking into account mixed-fisheries effects of some of the fleets.

EWG emphasizes that this is the first attempt to evaluate the exploitation state of the species using production model and SURBA and, therefore, it is necessary to analyze with other approach in order to confirm the results obtained for 2007 and 2008.

**Fisheries**

**Limit and precautionary management reference points**

| | |
|---|---|
| $F_{0.1}$ (mean) | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

| | |
|---|---|
| $F_{0.1}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

**Comments on the assessment**

The detailed assessment of Norway lobster in GSA22-23 can be found in section 2 (1.8) of this report.

## 1.23 **Summary sheet of red mullet (*Mullus barbatus*) in GSA 20**

| | |
|---|---|
| Species common name: | Red mullet |
| Species scientific name: | *Mullus barbatus* |
| Geographical Sub-area(s) GSA(s): | GSA 20 |

**Most recent state of the stock**

- <u>State of the adult abundance and biomass:</u>

In the absence of proposed or agreed references, STECF Ad hoc Working Group is unable to fully evaluate the state of the stock and provide scientific advice.
No reliable estimates on the trend in the spawning stock size can be assessed based on SURBA results, which presented poor data fit.

The current biomass estimated by the ASPIC model is 1.21 of BMSY (B/BMSY = 1.21), thus the current biomass is above the estimated biomass reference point for this stock.

- <u>State of the juvenile (recruits):</u>

No reliable estimates on the trend in the recruitment size can be assessed based on SURBA results, which presented poor data fit.

- <u>State of exploitation:</u>

The reference point estimated by ASPIC with the logistic model (0.27) suggests that red mullet in GSA 20 is exploited sustainably (Fcurr/FMSY in 2008=0.65).

No reliable estimates on the trend in F can be assessed based on SURBA results, which presented poor data fit.

F(0,1)=0.532 is proposed as proxy of Fmsy for this stock. According to the F estimates derived from LCA, F in 2008 was larger than FMSY. Based on this assessment, the stock of red mullet in GSA 20 is exploited unsustainably.

- <u>Source of data and methods:</u>

Landings and effort time series are from 1964 to 2008.

**Outlook and management advice**

ASPIC results suggest the stock is exploited sustainably, with the current exploitation rate ($F_{2008}$ = 0.20) lower than the estimated reference point ($F_{MSY}$=0.29 ). While the estimates of fishing mortality in the more recent available years are lightly lower than the values of the $F_{MSY}$ reference point, the current biomass is higher than the limit reference value ($F/F_{MSY}$= 0.65 and $B/B_{MSY}$=1.21). The maximum values for F were found among the years 1994-2004. While it is observed a decline in F in recent years, an inverse trend apply for Biomass, that in the recent years is about 26% higher than the $B_{MSY}$ level.

With VIT, the results suggest that the $F_{2008}$ is higher than the estimated value for the reference point $F_{0.1}$ considered a proxy of $F_{MSY}$ (mean $F_{2008} = 0.67$; $F_{0.1} = 0.53$. However, these last results have to be considered with precaution because they derive from the analysis of only one year, and many assumptions have to be done.

EWG emphasizes that this is the first attempt to evaluate the exploitation state of the species using production model and SURBA and, therefore, it is necessary to analyze with other approach in order to confirm the results obtained for 2007 and 2008. However, the current assessment (based on the ASPIC results) indicated that the stock is exploited sustainably and the biomass is larger than the biomass at MSY.

**Fisheries**

*Mullus barbatus* is among the most commercially valuable species in the areas and is an important component of a species assemblage that is the target of the bottom trawling fleets and small scale fisheries operating near shore. The small mesh size of the cod end in all cases defines a very precocious size/age of first capture. The species is mostly caugh by small-scale fisheries using set nets.

On average in the analysed period, the main catches of *Mullus barbatus* proceed in GSA20 from small scale fisheries (64%), while trawlers catches represent about 28% followed by beach seines (6%) and only 2% from purse seiners.

The exerted fishing pressure on this species on different GSAs may be quite different because conditioned by the structural composition of the fractions of the fleets that operate close to their respective ports, by the characteristics of the potentially exploitable grounds and also by differences in the fisheries' target choices among fleets and zones. *Mullus barbatus* catch rates are higher during the post-recruitment period (from September to November). The trawlers and the small scale artisanal vessels are the main categories that exploit the species in the studied areas.

**Precautionary and target management reference points or levels**

| | |
|---|---|
| $F_{0.1}$ = | |
| $F_{msy}$ = | |
| $F_{mean}$ (age range)= | |
| $Z_{msy}$ (age range)= | |
| $Z_{mean}$ (age range)= | |
| $B_{pa}$ (spawning stock) | |
| $B_{lim}$ (spawning stock) | |

Table of **agreed** precautionary and target management reference points or levels

| | |
|---|---|
| $F_{0.1}$ (age range)= | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |

| | |
|---|---|
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

**Comments on assessment**

The detailed assessment of red mullet in GSA 20 can be found in section 2 (1.10) of this report.

## 1.24 **Summary sheet of red mullet (*Mullus barbatus*) in GSAs 22&23**

| | |
|---|---|
| Species common name: | Red mullet |
| Species scientific name | *Mullus barbatus* |
| Geographical Sub-area(s) GSA(s): | GSAs 22&23 |

**Most recent state of the stock**

- State of the adult abundance and biomass:

In the absence of proposed or agreed precautionary reference is not possible to fully evaluate the status of the spawning stock size.
SURBA results, due to the poor data fit, are not considered reliable to evalute the status of the spawning biomass.
Results from the Length Cohort Analysis (VIT software) using as input DCR data of the annual length distributions of 2005 and 2008 does not show any particular trend in SSB.
The total biomass at sea in 2008 estimated with the production model using the logistic approach, is below $B_{MSY}$ (i.e. about 90% of $B_{MSY}$ ($B/B_{MSY}$ = 0.91)).

- State of the juvenile (recruits):

VIT recruits estimates were as follows: 3.44 x$10^5$ in 2005 and 3.07 x$10^5$ in 2008.
SURBA results, due to the poor data fit, are not considered reliable to evalute the status of the recruitment.

State of exploitation:
Based on VIT results, $F_{(0,1)}$=0.5 is proposed as proxy of $F_{msy}$ for this stock. According to the F estimates derived from LCA, F in 2005 and 2008, F was larger than $F_{msy}$. Based on this assessment, the stock of red mullet in GSA22-23 was exploited unsustainably.

According to ASPIC results, in 2007 the stock can be considered overexploited (current Fcurr/FMSY=1.18). A value of FMSY of 0.308 was estimated while the model estimated for the most recent year (2007) a value of F of about 0.32

- Source of data and methods:

VIT results suggest that the red mullet in GSA22&23 was exploited unsustainably in 2005 and 2008 as current F (0.56) was larger than the proxy of FMSY (F(0.1)=0.52).

According to ASPIC results, red mullet in GSA22&23 can be considered exploited unsustainably in 2007 (current F/FMSY=1.18). A value of FMSY of 0.308 was estimated while the model estimated for the most recent year (2007) a value of F of about 0.32
SURBA results, due to the poor data fit, are not considered reliable to evaluate the exploitation status of red mullet in GSA 22&23.

**Outlook and management advice**
STECF ad-hoc WG-reassessment of Greek stocks recommends the relevant fleets' effort or catches to be reduced until fishing mortality is below or at the proposed $F_{MSY}$ level, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a

multi-annual management plan taking into account mixed-fisheries considerations. Catches and effort consistent with $F_{MSY}$ should be estimated.

**Fisheries**

Landings data were reported to STECF ad-hoc WG-reassessment of Greek stocks through the DCR (2003-2008; no data for 2007) and Moutoupolous and Stergiou (2012) FAO-FISHSTAT GFCM database, for the period 1964- 2007. The majority of landings correspond to small scale and bottom trawl (on average 1964-2007, 46% and 48% respectively). During 2003-2008, landings displayed a decreasing trend, from 4322 t in 2003 to 2600 t in 2008 (DCR data).

**Limit and precautionary management reference points**

Table of limit and precautionary management reference points proposed by STECF EWG

| | |
|---|---|
| $F_{0.1}$ (ages 0-3) = | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (ages 0-3) = | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{0.1}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

The detailed assessment of red mullet in GSA 22&23 can be found in section 2 (1.11) of this report.

1.25 **Summary sheet of hake (*Merluccius merluccius*) in GSA 20**

| | |
|---|---|
| Species common name: | European hake |
| Species scientific name | *Merluccius merluccius* |
| Geographical Sub-area(s) GSA(s): | GSA 20 |

**Most recent state of the stock**

- <u>State of the adult abundance and biomass:</u>

Stock assessment has been computed by Length Cohort Analysis (VIT software) using as input DCR data of the annual length distributions of 2005.

The production model (ASPIC) did not return a reliable pattern in the stock trend. However, the general fit of the model is rather poor ($r^2$ is estimated to be around 0.20). Thus the EWG consider that the model output is not reliable for the assessment of hake in GSA 20.

SURBA analysis of the MEDITS data (1994-08) showed an increasing trend in SSB since 2003. Since no biomass reference levels for the stock of hake in GSAs 22&23 were proposed, STECF ad-hoc WG for the assessment of Greek stocks cannot evaluate the stock status in relation to these

- <u>State of the juvenile (recruits):</u>

VIT recruits estimate of recruitment was 249 x$10^{6}$ in 2005. SURBA analysis of the MEDITS data (1994-08) showed an increasing trend in recruitment since 2003.

- <u>State of exploitation:</u>

The production model (ASPIC) did not return a reliable pattern in the F trend. However, the general fit of the model is rather poor ($r^2$ is estimated to be around 0.20). Thus the EWG consider that the model output is not reliable for the assessment of hake in GSA 20.

The survey data (SURBA analysis) indicated an increasing pattern in $F_{1-4}$ since 2003.

STECF ad-hoc WG-reassessment of Greek stocks proposed $F_{0.1} \leq 0.27$ as proxy of $F_{MSY}$. According to the results of the Length Cohort Analysis the estimated F ($F_{1-4}$=0.89) was larger than $F_{MSY}$.

Based on the results of the LCA assessment, STECF ad-hoc WG for the assessment of Greek stocks considers the stock of hake in the GSA 20 is exploited unsustainably until 2007.

- <u>Source of data and methods:</u>

A Length Cohort Analysis (VIT software) was carried out using DCR data of landings and size structures 2005) for the main gear/fisheries (i.e. nets (GTR), long-lines, bottom trawling) exploiting the stock. SURBA was used to analyse the MEDITS survey indices in the period 1994-2008 and estimate the stock trend in mortality, SSB and recruitment. To this aim the MEDITS size compositions were converted in age compositions using a knife edge slicing. A natural mortality vector, obtained applying the PRODBIOM method, was used both in VIT and SURBA. $F_{01}$ as proxy of $F_{MSY}$ was estimated using a Yield per Recruit (YPR) model using VIT. An attempt to fit a surplus production (logistic) model to the official reconstructed data series (catch and effort estimates) was also done by means of ASPIC (Prager, 1994).

**Outlook and management advice**

STECF ad-hoc WG for the assessment of Greek stocks recommends the relevant fleets' effort or catches to be reduced until fishing mortality is below or at the proposed $F_{MSY}$ level, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries considerations. Catches and effort consistent with $F_{MSY}$ should be estimated.

**Fisheries**

Landings data for hake in GSA 20 were based on the reconstructed official landings as described in Moutopoulos and Stergiou (2012). The majority of the landings are reported by otter trawlers (10.9%) followed by small-scale gears (8.8%). The reconstructed landings for hake in GSA 20 by otter trawls ranging during the period 1964-2007 between 58.6 t, in 1964 and 874.1 t, in 2007, with a maximum of 930.7, in 1993. The reconstructed landings for hake in GSA 20 by small-scale gears ranging during the period 1964-2007 between 42.6 t, in 1964 and 1224.7 t, in 2007, with a maximum of 1902.7 t, in 1995.No particular description is provided. Landings data were reported to EWG 12-10 through the DCF. The majority of landings are reported by otter trawlers. Landings fluctuated during the period 2002-2011 with a maximum value of 4,723 t in 2006 and a minimum value of 1,276 t in 2003. Official fishing effort data (Kw*days) showed a decrease in effort since 2003 of both bottom otter trawlers (OTB) and small scale vessels using trammel nets. The reconstructed effort (Hp*days) however shows a rather different pattern for OTB with an increases since 2002 after a stable pattern during '90s.

**Limit and precautionary management reference points**

Table of limit and precautionary management reference points proposed by STECF EWG

| | |
|---|---|
| $F_{0.1}$ (ages 0-5) = | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (ages 0-5) | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{0.1}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

The detailed assessment of hake in GSA 20 can be found in section 2 (1.12) of this report.

### 1.26 Summary sheet of striped red mullet (*Mullus surmuletus*) in GSAs 22&23

| | |
|---|---|
| Species common name: | Striped red mullet |
| Species scientific name: | *Mullus surmuletus* |
| Geographical Sub-area(s) GSA(s): | GSA 22&23 |

**Most recent state of the stock**

- <u>State of the adult abundance and biomass:</u>

There are not agreed precautionary reference levels and hence is not possible to fully evaluate the status of the spawning stock size. SURBA results, due to the poor data fit, are not considered reliable to evalute the status of the spawning biomass.The total biomass at sea in 2008 estimated with the production model using the logistic approach, is below $B_{MSY}$ (i.e. about 90% of BMSY ($B/B_{MSY}$ = 0.88)).

- <u>State of the juvenile (recruits):</u>

SURBA results, due to the poor data fit, are not considered reliable to evalute the status of the spawning biomass.

- <u>State of exploitation:</u>

The estimated reference point ($F_{MSY}$ = 0.28) is above the values of current F estimated by Aspic (0.22). Thus, according to ASPIC results, in 2007 the stock can be considered sustainably exploited (current $F/F_{MSY}$=0.83).

- <u>Source of data and methods:</u>

Landings and effort time series are from 1964 to 2008.

**Outlook and management advice**

EWG emphasizes that this is the first attempt to evaluate the exploitation state of the species using production model, therefore, it is necessary to analyze the stock with other approaches in order to confirm the results obtained for 2007 and 2008. However, the current assessment indicated that the stock is exploited sustainably and the biomass is larger than the biomass at MSY.

**Fisheries**

*Mullus surmuletus* is one of the most important target species caught by trawlers and trammel netters in Greece (Tzanatos et al., 2005; Gozalvo et al., 2011) and is an important component of a species assemblage that is mainly targeted by the small scale fisheries operating near shore. On average in the analysed period, the main catches of *Mullus surmuletus* proceed in GSA22-23 from small scale fisheries (66%), while trawlers catches represent about 27% followed by beach seines (4%) and only 1% from purse seiners.

**Precautionary and target management reference points or levels**

| | |
|---|---|
| $F_{0.1}$ = | |
| $F_{msy}$ = | |

| | |
|---|---|
| $F_{mean}$ (age range)= | |
| $Z_{msy}$ (age range)= | |
| $Z_{mean}$ (age range)= | |
| $B_{pa}$ (spawning stock) | |
| $B_{lim}$ (spawning stock) | |

Table of **agreed** precautionary and target management reference points or levels

| | |
|---|---|
| $F_{0.1}$ (age range)= | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

**Comments on assessment**

The detailed assessment of striped red mullet in GSA 22&23 can be found in section 2 (1.13) of this report.

1.27 **Summary sheet of hake (*Merluccius merluccius*) in GSA 22&23**

| | |
|---|---|
| Species common name: | European hake |
| Species scientific name | *Merluccius merluccius* |
| Geographical Sub-area(s) GSA(s): | GSAs 22&23 |

**Most recent state of the stock**

- State of the adult abundance and biomass:

Stock assessment has been computed by Length Cohort Analysis (VIT software) using as input DCR data of the annual length distributions of 2004-06. The estimated SSB ranged between 5600 and 7818 t.

The production model (ASPIC) did not return a reliable pattern in the stock trend. However, the general fit of the model is rather poor ($r^2$ is estimated to be around 0.20). Thus the EWG consider that the model output is not reliable for the assessment of hake in GSA 22&23.

SURBA analysis of the MEDITS data (1994-08) showed an increasing trend in SSB since 1994. Since no biomass reference levels for the stock of hake in GSA 22&23 were proposed, STECF ad-hoc WG for the assessment of Greek stocks cannot evaluate the stock status in relation to these.

- State of the juvenile (recruits):

VIT recruits estimates ranged between 375 and 387 million in 2004-06. However, since no recruitment reference point for this stock has been proposed, STECF ad-hoc WG for the assessment of Greek stocks cannot it is not possible to evaluate the stock status in relation to these.

- State of exploitation:

STECF ad-hoc WG-reassessment of Greek stocks proposes $F_{0.1} \leq 0.24$ as proxy of $F_{MSY}$. The current $F_{1\text{-}4}$ was between 0.67 and 0.83 in 2004-06 and therefore larger than $F_{MSY}$.

The survey data (SURBA analysis) indicated an increasing pattern in $F_{1\text{-}4}$ since 1995 with $F_{1\text{-}4}$ between 0.79 and 0.86 in 2004-06 and 1.1 in 2007, therefore in line with the VIT estimates.

Based on the LCA assessment, STECF ad-hoc WG-reassessment of Greek stocks considers the stock of hake in the GSA 20 exploited unsustainably until 2007.

- Source of data and methods:

A Length Cohort Analysis (VIT software) was carried out using DCR data of landings and size structures (2004-06) for the main gear/fisheries (i.e. nets (GTR), long-lines, bottom trawling) exploiting the stock. SURBA was used to analyse the MEDITS survey indices in the period 1994-2008 and estimate the stock trend in mortality, SSB and recruitment. To this aim the MEDITS size compositions were converted in age compositions using a knife edge slicing. A natural mortality vector, obtained applying the PRODBIOM method, was used both in VIT and SURBA. $F_{01}$ as proxy of $F_{MSY}$ was estimated using a Yield per Recruit (YPR) model using VIT.
An attempt to fit a surplus production (logistic) model to the official reconstructed data series (catch and effort estimates) was also done by means of ASPIC (Prager, 1994).

**Outlook and management advice**

STECF ad-hoc WG for the assessment of Greek stocks recommends the relevant fleets' effort or catches to be reduced until fishing mortality is below or at the proposed $F_{MSY}$ level, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries considerations. Catches and effort consistent with $F_{MSY}$ should be estimated.

**Fisheries**

Landings data were reported through the DCF. The majority of landings are reported for otter trawlers, with long-liners and small-scale vessels using nets reporting about 50% of the annual landings, as estimated from the size distributions by gear. Landings fluctuated during the period 2003-2008 with a maximum value of 9.079 t in 2006 and a minimum value of 4986 t in 2003. Discards data and 2007 data were not available.

The effort of trawlers increased continuously since 1965 whereas the small scale fishery showed a strong increase in the period 1965-1990 followed by a decreasing since then.

**Limit and precautionary management reference points**

Table of limit and precautionary management reference points proposed by STECF EWG

| | |
|---|---|
| $F_{0.1}$ (ages 0-5) = | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (ages 0-5) = | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{0.1}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

The detailed assessment of hake in GSA 22&23 can be found in section 2 (1.14) of this report.

## 2 ANNEX I LIST OF PARTICIPANTS TO STECF AD-HOC WORKING GROUP ON ASSESSMENT OF SOME GREEK STOCKS

| Name | Address | Telephone no. | Email |
|---|---|---|---|
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Abstract

The Ad-hoc Working Group of the Scientific, Technical and Economic Committee for Fisheries EWG worked by correspondence to conducut assessemts of *Merluccius merluccius*, *Mullus barbatus*, *Mullus surmuletus*, *Boops boops*, *Spicara smaris/Spicara flexuosa* and *Nephrops norvegicus* in Aegean and Ionian waters. The report was reviewed by the STECF during its 41st plenary held from 5 to 9 November 2012 in Brussels (Belgium).

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